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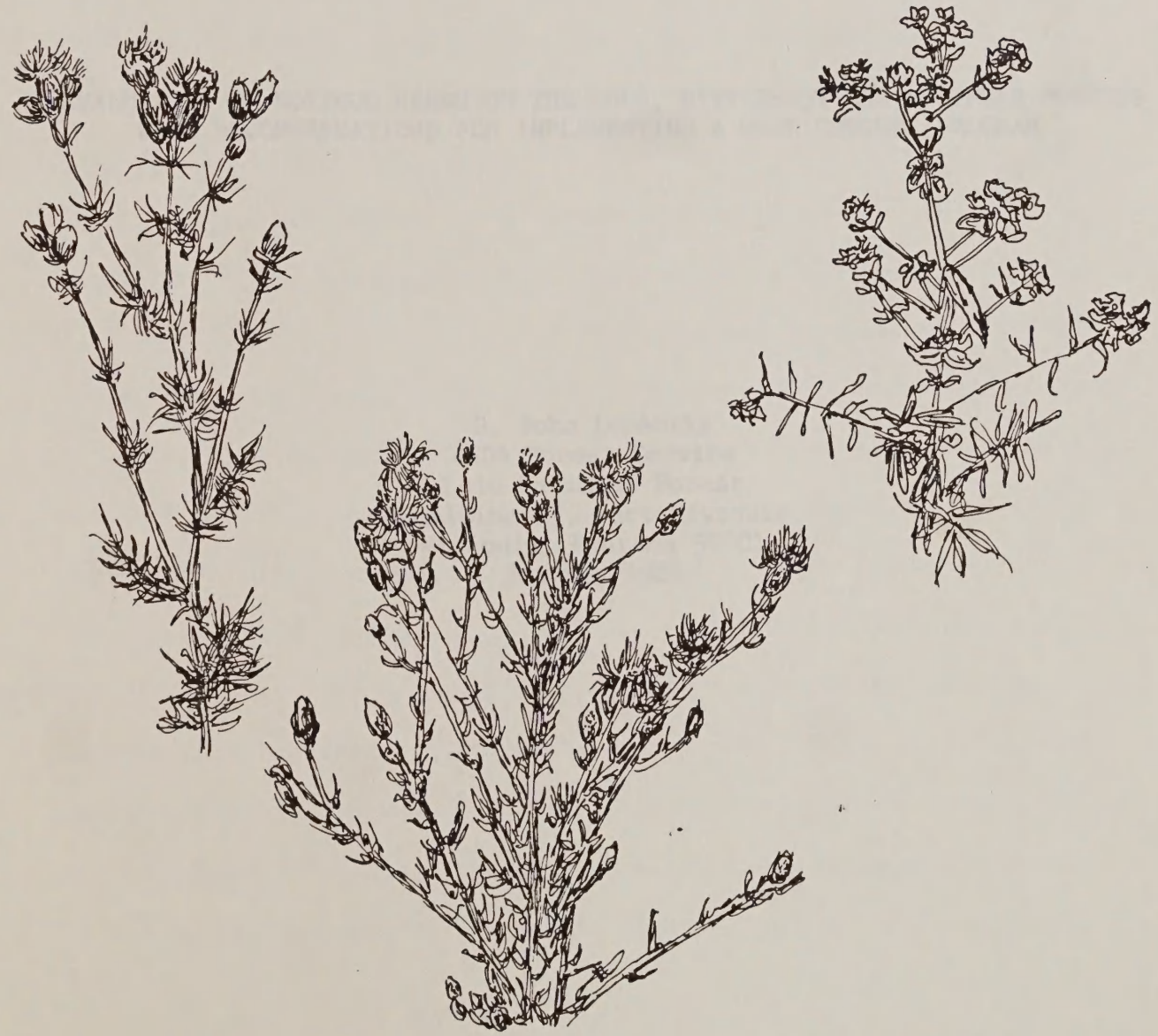

AN EVALUATION OF NOXIOUS WEEDS ON THE LOLO, BITTERROOT AND FLATHEAD FORESTS WITH RECOMMENDATIONS FOR IMPLEMENTING A WEED CONTROL PROGRAM

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

This paper reviews the literature on 9 important noxious weeds found on the Bitterroot, Lolo and Flathead National Forests. Weeds studied were; spotted knapweed, diffuse knapweed, Canada thistle, musk thistle, goatweed, houndstongue, leafy spurge, tansy and dalmation toadflax. When available, information is presented on the life cycle for each weed. The literature review shows a lack of studies on weeds in a forest environment.

The results of a field investigation are also reported. Field investigations were focused in particular on the response of each weed to tree canopy shading, competition with native ground vegetation and the effect of the weed on tree growth. Studies were conducted on roads and sites disturbed by management activities. Observations indicate that with the exception of houndstongue and tansy, canopy coverage affected the survival and growth of our major weeds. While goatweed and leafy spurge can maintain themselves vegetatively under a canopy, plants were normally lax and did not flower.

Response of weeds to disturbance by activities such as roading and site scarification were variable and depended to a great degree on the habitat type, aspect, amount of canopy remaining, and extent of disturbance. Spotted knapweed was particularly sensitive to canopy coverage both in its occurrence along roads and its invasion and domination of other disturbed sites. Models are presented that may be useful in predicting the potential for invasion onto various sites by knapweed and Canada thistle.

Based on the finding of the study, a number of recommendations are presented for a strategy of noxious weed control. These include changes in present management activities, biological control opportunities, education of Forest personnel and other containment options.

INTRODUCTION

Noxious weeds have been a problem on National Forest land for years. Various control measures have been attempted; however, noxious weeds have continued to spread. In 1983 a staff paper (Spoon 1983) was prepared by the Lolo National Forest to focus attention on noxious weeds on National Forest lands. Concurrently a growing public concern about the threat of noxious weeds in conjunction with ground disturbing activities on forest lands has developed. Currently a number of Forest Plans are under appeal for their treatment of noxious weeds. A new weed law (_____1985) was passed in Montana which also has focused attention on this issue.

It is apparent that a reassessment of our noxious weed program is necessary. To that end this study was initiated to provide background information to assess the weed problem and provide the basis for development of reasonable alternatives. Objectives of the study were:

1. Review the literature to provide an understanding of the life cycle of each weed and available control methods.

2. Develop through field observations a risk rating for the various vegetative communities in the study area.

3. Develop recommendations for weed control emphasizing biological control and/or management strategies.

The information presented in this paper will hopefully provide the groundwork for a new and innovative approach to noxious weed control.

The study area included the Bitterroot, Lolo and Flathead National Forests. It focused on forest communities because of the major area they represent and the potential threat of weed invasion resulting from ground disturbing activities such as road construction, timber harvest and site preparation. Unfortunately most studies conducted to date have dealt with weeds in cropland or rangeland conditions. Very little work has been done in forest communities. Differences in community structure can result in major changes in the role individual noxious weeds will play in the community. Potential impacts developed on the basis of studies in grassland communities may not be applicable to forest communities. For example, the concept that once a weed becomes established it could dominate the community may be true in a range community but it may not be an appropriate concept in a forest community. Casual observations suggest that shrub and tree species are generally very competitive with weeds.

The noxious weeds evaluated are those designated by the State of Montana and do not represent all the introduced species found on the three Forests. Other than in a general sense, no attempt was made to map existing weed populations on the Forests as time did not permit a complete review of the study area. While herbicides may be considered in developing a control strategy, this review focused on non-herbicidal alternatives which may be applied to the vast acreages of National Forest land.

PRESENT SITUATION

Although estimates have been made on the extent of various weeds on National Forest lands, few inventories have been undertaken to validate the extent of the problem. In the past 2 years a systematic evaluation has been undertaken on the Flathead Forest to assess the miles of road infested by noxious weeds. This information will be valuable in determining problem areas, highlighting types of environments that are at risk, and providing a basis to assess the success or failure of control programs.

To date there has been no systematic evaluation made of our forested communities for noxious weeds. This type of inventory will require considerably more investment of time and money; however, some type of inventory will be necessary to implement a control program. It may be reasonable to implement a program of eradication on a weed if there is only 50 acres on the forest, but if the acreage is in fact closer to 1000 acres, a program of containment may be more realistic. Unless good estimates of acreages and their locations are known, our control programs may not be applicable. Hopefully Forests will conduct an inventory to provide the basis for developing a strategy of control and monitoring.

A review of over 200 articles in the literature was conducted to assess information that is available on each plant's life cycle and methods that have been used in their control. The field review included 131 plots taken on forest roads to assess the ability of noxious weeds to occupy these sites under various environmental conditions. The coverage of each noxious weed was determined using the rating system presented in Appendix A. Other factors recorded were weed height, aspect, canopy closure, habitat type and a factor that represented the resident sunlight on the road shoulder. Many miles of road were surveyed to determine elevational limits and habitat types that were occupied by noxious weeds on the three Forests. Observations were made on both the road prism and on the adjacent communities. In addition 68 plots were taken on disturbed sites to determine the success of noxious weeds in occupying a site as a result of our management activities. This information was evaluated using regression analysis to develop the models presented in Appendix D and E. The field review and information obtained from the literature review was used in developing the risk rating presented in Appendix A and in developing the recommendations.

IMPORTANT NOXIOUS WEEDS

The following weeds are species found on National Forest land and are designated as noxious by the State of Montana. Based on available acreage estimates spotted knapweed is by far the most significant problem on all three Forests in acres affected. It is widespread in many environments at all elevations and aspects. A distant second is goatweed. While a serious problem in grassland communities, its impact in the forest environment is limited. Houndstongue and Canada thistle are the two other species that are found in significant amounts. While there is a high number of acres infested by Canada thistle, it is generally at a very low level and of limited impact on management. Leafy spurge is of particular concern because of its potential to spread quite rapidly and the extreme difficulty of control once it is

established. The remaining species have limited acreages on the Forests at this time. Appendix C gives an estimate of acres of each weed by Forest.

Spotted Knapweed - Centaurea maculosa

Characteristics

Spotted knapweed is a biennial or short-lived perennial forb in the sunflower family with showy, purple or occasionally white flowers. Length of life averages between 3 to 5 years (Watson 1974). Spots on the bracts separate this knapweed from the other knapweeds which are found in Montana (Lacey & Lacey 1985).

Spotted knapweed is found on a wide range of soils with the density of plants correlated with aspect, soil type and the degree of soil disturbance. It is most commonly found on dry sterile, gravelly, or sandy soils in pastures, and will quickly invade disturbed sites such as road and railroad right-of-ways, waste places, abandoned fields, and overgrazed rangeland (Reed 1970). While it may be found on ungrazed rangeland, it is not common on cultivated land nor on irrigated pasture. The knapweeds prefer open habitats and are not commonly found in shaded areas.

Knapweed is very competitive on dry sites because of its early spring growth and is found mainly in the 25-to 30-inch precipitation zone (French 1983, Schirman 1981). Seedlings of knapweed germinated equally well under a range of canopy cover (0 to 100 percent); therefore the reduced number of plants under a canopy must result from seedling mortality. Seedlings have the highest emergence rate when they are on the soil surface and have only limited germination when buried at depths greater than 0.8 of an inch (Spears 1980). Spotted knapweed overwinters as a rosette or in seed form. Severe winter conditions cause rosette mortality; however, the population is not adversely affected because of the large number of seeds germinating in the spring. Seeds germinate over a wide range of environmental conditions; but optimum germination occurs with a soil moisture between 55 and 70 percent and air temperatures between 45 to 93 degrees. Moisture appears to be the most limiting factor for germination, and emergence rates decreased with soil moisture above 70 percent (Spears 1980). Spring germinates emerge in early April through the end of May and form a rosette. Plants normally remain in the rosette stage the first year and then grow to a height of 1 to 3 feet. If conditions are favorable they will bolt, flower and set seed from early July to mid-August. Seeds that germinate in the fall or rosettes that did not bolt the first season will overwinter as a rosette and then bolt and set seed from May through the end of June. It may regrow from the root crowns for a number of years and can reproduce vegetatively from lateral shoots just beneath the soil surface (Spears 1980, Schirman 1981).

Seed production is approximately 1000-fold that needed to maintain observed levels of infestation (Schirman 1981). The average plant produces about 1000 seeds, and 30,000 to 40,000 seeds per 1.8 square feet (.5 square meter) are produced annually in a mature stand (Chicoine 1984). Seedling density ranges between 500 to 1,000 seedlings per 1.8 square feet (.5 square meter) which leaves about 98 percent of the seed available to add to the seed bank. On

these sites it will take in excess of 6 years to exhaust the seed bank if seed production is stopped (Chicoine 1984). Other studies suggest that seed may remain viable for up to 8 years (French 1983). Areas disturbed by overgrazing and road construction can be completely covered with knapweed in one season. Annual seed production of knapweed is reduced in dry years by a reduction in the number of viable seeds per head and increased when above-normal precipitation occurs by increasing the number of heads/flower stem.

Populations in well managed rangelands do not increase rapidly (Watson 1974). It does not compete well with vigorously growing grass in moist sites nor with diffuse knapweed in steppe grasslands (Harris 1979). Other weeds such as goatweed and leafy spurge will also outcompete knapweed. Populations extend largely through peripheral enlargement of existing stands. Transportation on equipment, attached to animals or on clothing, and with animal feed have been major methods for establishment of new populations.

Recent work by Willard (_____1986b) found knapweed success in all habitat types correlated with degree of disturbance and moisture-stressed environments. In habitat types moister than the Douglas-fir group, disturbance intensity had the greatest influence although soil texture and topographic position are also important. In the grass and shrub habitat types, aspect was the most important variable followed by disturbance intensity. In the intermediate conditions no consistent variable was identified.

Knapweeds have been determined to produce allelopathic effects on other plant species through the production of cnicin (Watson 1974). Although some plant species were inhibited at concentrations between 1 to 4 mg. the most significant inhibition usually began to occur around 4 mg. or greater. Bluebunch wheatgrass and knapweed seedlings are inhibited significantly at all concentrations. Cnicin is limited in roots and flower heads and is greatest in the leaves. Highest observed concentrations (about 3 percent) occurred in October in dead plants. Only trace quantities of cnicin were detected in soil extracts during the growing season. Since little is found in the roots or soil it appears cnicin acts primarily as a chemical defense against herbivores and disease and any direct allelopathic activity is secondary and is not very ecologically significant (Kelsey 1985). With knapweed removal regrowth of grass was not influenced by the previous density of knapweed, therefore allelopathic substances do not remain in the soil (Myers 1983).

Results of field review and analysis

As is readily apparent, spotted knapweed is the most widely distributed weed on the three Forests. Samples taken on roads indicate that it is capable of growing in all but the high elevation sites represented by subalpine fir/woodrush (Abla/Luhi, See Pfister 1977 for a complete description of habitat types described in this report) or above. Regression analysis has shown, however, a strong correlation between knapweed coverage and tree crown closure over the road, an expression of the residency time of direct sunlight on the plant and aspect. Appendix D presents the results of this model. While knapweed can grow along roads in a wide variety of sites, unfavorable light conditions will prevent its establishment. Many examples were noted on existing roads where dense stands of knapweed ended abruptly where the crown of

a tree or shrub shaded the road shoulder. Tree species composition was not evaluated, but it is apparent that crowns of tolerant tree species have more impact on knapweed survival than intolerant species. Tolerant species have dense crowns which restrict light passage, and normally stands composed of tolerant species will have a greater number of individuals resulting in a higher crown closure. Worst case infestations occurred on southwest aspects where the road was oriented in a north-south direction with no tall vegetation adjacent to the road. A correlation was not found with elevation although general observations suggest that above 5500 feet on the Flathead, 6000 feet on the Lolo, and 6500 feet on the Bitterroot Forest knapweed will be common only on severe southerly aspects. Gravelly textured soils appear to be high risk for knapweed invasion when disturbed in all environments.

There is a concern that knapweed will spread from roads into the forest communities: however, the analysis indicates that a majority of the vegetative communities on the Forests are resistant to invasion even after logging and moderate cattle grazing. There are, however, a number of types that are threatened:

1. Ponderosa pine and/or Douglas-fir bunchgrass types - These types are normally found at low elevation adjacent to grassland communities which are commonly infested with spotted knapweed. Past grazing practices and/or soil type may play an important role in determining the extent that knapweed has invaded these open timber types. Examples of heavily grazed areas were noted that now support dense stands of knapweed. Robust Idaho or rough fescue communities appear able to withstand knapweed encroachment as long as the grass community is not damaged by treatments such as scarification. Steep south slopes with numerous areas of bare soil, gravely or granitic soils are at risk regardless of the use. Grazing on these sites usually compounds the risk. Wheatgrass communities are more susceptible to invasion because of the plant's sensitivity to allelopathic conditions.

2. Dry shrub communities such as Douglas-fir/snowberry (Psme/Syal) and Douglas-fir/ninebark-pinegrass (Psme/ Phma-Caru). Sites where Psme/Syal is present can be dominated by knapweed after dozer scarification since the heights of knapweed plants compared to snowberry permits it to gain sunlight. Mature stands in the snowberry type generally have open tree canopies which provide sufficient sunlight to the forest floor to permit knapweed growth. While knapweed does not compete well with ninebark, the pinegrass phase of the Psme/Phma type has a significant area which is occupied with pinegrass and/or bunchgrasses. In these situations knapweed can dominate these grass interspaces for extended periods.

3. Scree types - At the lower elevations, knapweed can move into these types relatively easily because of the amount of bare soil and rocky nature of the site. This movement is occurring independently of any disturbance; however, roading and grazing can speed up the process.

On sites that have been disturbed through logging, analysis of plot data collected indicates that the risk of knapweed establishment is positively

correlated with coverage of ceanothus (Ceanothus velutinus) and inversely correlated with tree crown closure, total shrub coverage, and the presence of pearly-everlasting (Anaphalis margaritacea). If the site is in one of the high risk types listed above and knapweed is present on the road through the unit, there is a strong likelihood that knapweed will move into the unit with disturbance especially dozer piling. The model will be helpful on these sites plus others for evaluating this potential. See appendix E for a complete description of the model.

Management implications

The impact of knapweed in forest communities has had limited study. Recent work with ponderosa pine seedlings found no impact from knapweed on survival and growth from an allelopathic agent. Knapweed litter applied to the soil at rates of 0 to 16,000 lbs /acre did not significantly affect growth of ponderosa pine seedlings (_____ 1986b). Normal competition for moisture, however, may be important to seedling survival.

Forage loss for wildlife and the loss of transitory range for cattle are significant. Continued cattle use of infested ranges will increase the problem as they preferentially graze the grasses and shrubs providing knapweed ideal growing conditions. While cattle will occasionally utilize knapweed, its heaviest use is associated with overused ranges or along roads where food is limited. Recent studies have found some deer and elk use of knapweed flowers on winter ranges but again it may be because of the lack of other food sources (_____1986b).

There were no noticeable impacts from knapweed on shrub response after site disturbance, and other than snowberry most forest shrubs can shade out knapweed. Snowberry does not restrict knapweed significantly nor is snowberry apparently affected by knapweed in its growth.

Most heavy infestations of knapweed in the forest environment are related to activities such as dozer piling which removed the natural vegetation. Reestablishment of forbs and grasses may be retarded by knapweed but except for the high risk areas mentioned above, there is no evidence that knapweed will prevent their reestablishment particularly if the tree canopy coverage increases. Wheatgrass may be an exception to this finding. Moderate to heavy grazing plus maintaining very open tree canopies will retard or prevent normal succession and can maintain heavy knapweed populations indefinitely.

Presently spotted knapweed represents the greatest threat of all noxious weeds to forest ecosystems. Because of the widespread distribution of the plant all areas that are disturbed are at risk to knapweed invasion. While disturbed sites will revert to near normal plant communities with canopy coverage development, the more open grown tree communities will continue to contain significant amounts of the weed. Road corridors that are invaded with knapweed will continue to support it indefinitely. Without a change in management practices knapweed will continue to expand and in some cases dominate the forest vegetation.

Knapweed is considered out of control in the counties in which the three

Forests are located. The movement from National Forest lands to private lands probably is of limited importance to the control of knapweed except in cases where the landowner has an active program of knapweed control. It will be difficult, however, for landowners adjacent to National Forest land to implement any type of effective control program without an active program on the Forests.

Control measures

At present there are limited options for knapweed control on areas that are already infested. Huge seed reserves makes it impractical to pull or spray unless the program can be continued for at least 8 years. Mowing can provide some containment where grass is present and may be effective in campgrounds or similar sites. While knapweed will not be eliminated by this treatment it will reduce the amount of flowering and its dominance of the site. Deep plowing can eliminate knapweed by covering the seed. The application of fertilizer on heavily infested areas resulted in enhanced weed growth. Sheep grazing may provide some knapweed containment (French 1983). These treatments have also been suggested as ways to reduce the chance of allelopathic compounds getting into the soil from the plants aerial parts. Prescribed fire in combination with herbicides did not improve knapweed containment. Prescribed burning alone does not change knapweed density or production significantly (_____ 1986a).

Spotted knapweed can be controlled with herbicides, but the large seed reserves commonly found in stands of knapweed require that treatment be continued for an extended period. Spraying with 2,4-D just before the knapweed plant bolts is very effective on existing plants, but has no effect on the seed bank. Tordon is not as effective on plants but will provide almost 100 percent control on germinating seed. A mixture of 2,4-D and Tordon is commonly used which provides control for about three years.

A number of biological control agents have been introduced into Montana. The seed head flies Urophora affinis and U. quadrifasciata can cause up to a 95 percent reduction in seed numbers, but the remaining 5 percent can maintain the knapweed population (French 1983, Story 1979). Both flies are well established in Montana. Because of the huge seed bank and and annual seed production, limited success is expected with most seed feeding insects. The root boring moths Pelochrista medullana and Agapeta zoegana will bore into the root of knapweed severely injuring or killing the plant. Work is currently under way near Corvallis, Montana to evaluate A. zoegana (Monnig 1986). The fungus Sclerotinia sclerotiorum reduced knapweed coverage by 78 percent and increased grass cover by 59 percent compared to an untreated stand (_____1986a). Bedunah (_____1986b), has found the most effective isolates have resulted in a five-fold decrease in knapweed cover and a 190 percent increase in grass cover for two years of treatment. Wide-spread dispersal of this pathogen is limited in Montana by environmental conditions and the inability of the fungus to traverse more than a few inches of soil (_____ 1986a). Work is currently ongoing with mutational variants of this fungus at Montana State University. The host specificity of the variant under study has been narrowed such that it no longer attacks sunflower, safflower and legumes (Monnig 1986).

It is estimated that it will require at least 6 major biological agents to effectively control knapweed at an estimated cost of 1.8 million dollars (Harris 1979).

Based on the results of this study, I recommend a strategy that would attempt to contain existing infestations and prevent the establishment of new populations as a result of our management activities.

Diffuse Knapweed - Centaurea diffusa

Characteristics

It is a biennial herb with a mean length of life of 2 years belonging to the sunflower family (Watson 1974). The plant reaches 1.5-2.5 feet tall and has solitary white flower heads (Reed 1970). The flower heads have rigid spines that make them very spiny to the touch which seriously impairs the recreational potential of any site that it invades (French 1983). Diffuse knapweed is able to out-compete other vegetation over a relatively narrow range of moisture conditions (Berube 1982). It requires an arid period in the summer when the monthly precipitation curve falls below the temperature curve (Harris 1979). It grows on sites drier than those occupied by spotted knapweed (16-20 inches precipitation zone for diffuse knapweed and 25-30 inches for spotted knapweed)(Schirman 1981, Watson 1974). Germination of seed is not affected by plant canopy coverage. Diffuse knapweed cannot tolerate as great a seeding depth as spotted knapweed, and no germination occurrs in seed buried more than 3/4 inch in depth (Spears 1980). Generally it will not regrow after producing seed whereas spotted knapweed may produce seed more than 1 year. Seed production can reach 18,248 seeds per plant but more commonly will be about 1,000. Seed dispersal is mainly by wind occurring when the mature plants break off at ground level and become tumbleweeds. Vegetative reproduction does not naturally occur (Watson 1974).

A study of a lightly grazed grassland in the interior Douglas-fir zone showed diffuse knapweed invasion. The presence of 15 flowering plants per square yard reduced growth of grass during the summer about 2/3 and grass biomass by 1/2. The front of the knapweed distribution advanced about 394 feet during a 3-year period. Scattered patches of plants occurred further into the grassland which suggests that overgrazing is not a prerequisite to invasion of diffuse knapweed (Myers 1983). Diffuse knapweed forms large dense infestations, but solitary plants and small patches are common in recently invaded areas (Watson 1974). Fertilizer on moist areas helps knapweed but may be effective in stressing it on drier than optimal sites (Berube 1982, Watson 1974). A growth inhibitor similar to that found in spotted knapweed is also present in diffuse knapweed (Muir 1983).

Results of field review and analysis

Limited occurrences of diffuse knapweed have been noted to date on the three Forests. This may be the result of its similarity to spotted knapweed, and during an extensive survey, diffuse knapweed may be overlooked. Two locations were investigated on the Lolo Forest. There is a relatively large population in Nemote Creek which occurs in a Douglas-fir/ninebark (Psme/Phma) and a

Douglas-fir/huckleberry (Psme/Vagl) habitat type on the road and along heavily disturbed skidtrails. A heavily logged and grazed area in the riparian zone on private land has a good population on gravelly soils. No diffuse knapweed was found above 5000 feet in elevation. The other location is in a grass community near Cyr, Montana. Most of the plants found are associated with an old road through the area. Other locations are known in Superior County such as along the road to Thompson Peak and in the Miller Mountain area.

While no diffuse knapweed was noted on the Bitterroot Forest during the study, the environment is such that major portions of the Forest are at risk. The Flathead Forest should have limited areas that are at risk.

Management implications

To date diffuse knapweed has been found on a limited acreage. While the impact can be similar to spotted knapweed on forage production, its more limited environmental window reduces its overall risk to management. Study results suggest that the ponderosa pine and the dry Douglas-fir types including Douglas-fir/ ninebark-pinegrass (Psme/Phma-Caru) are at risk. Appendix A provides a risk rating for all the habitat types.

Control measures

In a particularly dry area of British Columbia invasion was prevented by a vigorous stand of crested wheatgrass (Myers 1983). Russian wild rye was moderate in reducing diffuse knapweed while crested wheatgrass had very low knapweed density (Berube 1982). Irrigation eliminates diffuse knapweed, and dense knapweed stands stop abruptly with an increase in soil moisture near temporary and permanent streams. With knapweed removal the growth of grass was not influenced by the previous density of knapweed; therefore, allelopathic substances do not remain in the soil (Myers 1983). Mowing in the flowering stage can cause a significant decrease in the number of plants that produce seed. Burning has been shown to be an effective containment measure for diffuse knapweed when found in a vigorous grass community. Deep plowing (7 inches) eliminated knapweed but incompletely covered crowns regenerated readily (Watson 1974).

Response to herbicide treatment is the same as that of spotted knapweed.

Biological control is limited because of the plant's seed producing potential. Urophora affinis or U. quadrifasciata can destroy up to 80 percent of the seeds in each flower head but that is not enough to reduce populations of weeds to below an economic threshold (Maddox 1982).

A root-boring beetle Sphenoptera jugoslavica was released in large numbers in Montana in 1986. The beetle is specific to diffuse knapweed and is well established in Oregon and Washington. The beetle has the ability to kill the plant, but no estimates are available as to its success (_____1986b).

The fungus Sclerotinia discussed under spotted knapweed is also being evaluated for containment of diffuse knapweed. Missoula County has determined that this is one of the weeds they want to keep out of the County. Two of the locations

found on the Lolo Forest are within about 3 miles of the County line. Recently a plant was found on private land in Lolo Creek within the Forest boundary which is in Missoula County.

Based on the present distribution and extent of this weed, I propose that our control effort be eradication. In some locations this objective will require a long-term commitment to follow-up treatments.

Canada Thistle - Cirsium arvense

Characteristics

It is a perennial herb in the sunflower family which reproduces by seeds and horizontal roots. The roots may extend several feet into the soil or may form extensive creeping horizontal mats which are generally within 3 to 12 inches of the surface. Stems are erect, hollow and average 4 feet tall. Flower heads are dioecious, numerous, and compact in clusters (Hodgson 1968). Because of its dioecious nature, many patches of thistle cannot produce viable seed because the stand originates from one plant. The weed is frequently seen in grassy opening in woods and on the margins of woods (Moore 1975). It normally is found in cultivated fields, meadows, pastures and waste places. It has been defined as a weed with low vigor and does best on cultivated or disturbed sites. It prefers rich, heavy soils but can survive in very dry soils; however, it grows poorly in very moist, poorly aerated soils (Reed 1970). Canadian collections have been made in areas described as clay loam, sandy loam, sandy clay and even sand dunes (Moore 1975). Clay soils are best for thistle, but they can survive in any soil except peat.

Most researchers agree that fresh seed will germinate well and does not require a dormancy period (Moore 1975). Soils saturated with water are poorly aerated and reduce seed germination. Osmotic pressures of 7 bars and greater reduce germination although 2 percent of the seeds germinated at 15 bars. These seedlings could not survive if the drought conditions persisted. Optimum ph for growth is between 5.8 and 7 with below 5 and above 7 resulting in inhibited germination. It can survive a salt content of up to 2 percent. Depth of planting influenced emergence with the highest percent emerged from depths of .2 to .6 inches (Wilson 1979). Germination from seed buried below 1.2 inches was less than 1 percent (Zilke 1967). Optimum germination occurred at alternating temperatures of 68 to 86 degrees and at a constant temperature of 86 degrees (Wilson 1979). Emergence of a shoot did not begin until the mean weekly temperature was 42 degrees or higher and was greatest above 46 degrees. Studies in Montana suggest that shoots begin to emerge in early May, develop rosettes with vertical growth commencing about 3 weeds after emergence. The most rapid growth occurs in the last 2 weeks of June (Moore 1975). In Canada it is found in areas with a mean January temperature of 19 to -8 degrees. It is apparently limited by high summer temperatures (Moore 1975). New seedlings establish slowly and seem to be quite sensitive to shading or competition. Seedlings can tolerate average soil moisture tensions of 1.3 bars and continue to grow. Seedlings subjected to average moisture tensions of 1.7 bars did not survive (Wilson 1974). Seedlings died when light intensity fell below 20 percent of full daylight (Hodgson 1968). Seedlings 19 days old were able to resprout after top-growth was removed. Regrowth was evident on 8 percent of

the clipped plants 4 days after initial top-growth removal.

Canada thistle is a long-day plant and flowering does not occur when light periods are under 8 to 12 hours. Considerable flowering will occur when light periods are 18 hours (Hodgson 1968). In shade, plants become tall and lax and produce few flowers (39 shoots per square meter with 41 heads per shoot in the open versus 11 shoots per square meter with 18 heads per shoot in a shaded forest habitat). Seed production varies from 3 to 103 seeds/head with a germination percent of from 53 to 96 percent (Wilson 1979). Seed viability was 90 percent for fresh seed, 50 percent for 2-year-old seed and 8 percent for seed 4 to 5 years old (Zilke 1967). Wind dispersal while limited is possible. Water also is a carrier, and seed can maintain viability for up to 4 months in water (Wilson 1979, Bruns 1957). Plants may produce up to 5,300 seeds, but the average production is about 1500 (Moore 1975). Seed remained viable in the soil up to 20 years (Hodgson 1968). The plant can also spread rapidly by means of an extensive rhizome system which can be a significant factor in the expansion of the plant (Beuerman 1984, Lauridson 1983). Canada thistle infestations degenerate behind an advancing front. While dense and numerous thistle at the periphery spread rapidly, the thistles near the center of the patch are sparse and less vigorous (Peschken 1981).

Studies suggest that Canada thistle can have allelopathic impacts on crop growth. Low species diversity accompanied high populations of thistle. When root and shoots of Canada thistle were mixed in the soil it reduced the growth of sugar beets, wheat, alfalfa, and Canada thistle seedlings. These effects lasted up to 60 days (Stachon 1980, Wilson 1981). Addition of nutrients did not mask the toxic effect (Stachon 1980). In another study as the shoots of Canada thistle increased, the number of mock cypress Kochia scoparia, tall marsh-elder Iva xanthifolia and foxtail barley Hordeum jubatum plants decreased and as Canada thistle decreased they increased (Wilson 1981).

Results of field review and analysis

Like most of the other weeds studied, Canada thistle was commonly found on all Forests in conjunction with disturbance. Three major environments were found to contain significant amounts of thistle:

1. Riparian zones with heavy cattle grazing - This is particularly a problem where grazing along with logging has converted the riparian zone to a bluegrass community. Dense stands of thistle are common and maintained by cattle use on competing vegetation.

2. Old burn piles - Sites where dozer piling and burning were employed often contain dense stands of thistle in the old burn piles. The amount of heat transferred to the soil seemed to have a bearing on the amount of thistle present. Hot burns appear to contain more thistle than cooler burns.

3. Road construction - Thistle was common along road shoulders at all elevations and habitat types with the exception of some of the very dry types. The amount of thistle increased with grazing pressure. While thistle is affected by shading a correlation with shade was not found in

the areas studied. Thistle was found in the subalpine fir/woodrush-whortleberry (Abla/Luhi-Vasc) habitat type. However, only 25 percent of the flower buds were in bloom during the first week in September, and it is questionable that viable seed can be produced before they are killed by frost.

No correlation could be found between various factors and the coverage or height of thistle on roads. On disturbed areas studied there was a correlation between the coverage of thistle and aspect. The amount of thistle was predicted to be 10 times greater on north aspects as compared to south aspects. The height of thistle was correlated with aspect and the coverage of bluegrass. This suggests a need for a moist environment and a strong association with cattle grazing.

Common species found with thistle on disturbed sites are Oregon grape (Berberis repens), blue grass (Poa spp.), and fireweed (Epilobium angustifolium) with lessor amounts of spirea (Spiraea betulifolia), strawberry (Fragaria spp.), and elk sedge (Carex geyeri). Thistle was limited on very dry types such as Douglas-fir/rough fescue (Psme/fesc).

Observations suggest thistle can maintain its position in the forest community only for short periods without continued disturbance particularly grazing. A prescribed burn which contained dense thistle the year following the burn contained only scattered plants in a dense overtopping stand of grass by the third year. Thistle is not very competitive with the native plant community and normally will be replaced in all but the most severely disturbed sites within about 5 years.

Management implications

My review suggests that Canada thistle does not pose a serious threat to National Forest lands. There is no indication that the plant is capable of developing dense stands for extended periods without some major disturbance. Dense stands may be found on areas subjected to hot burns particularly when dozer piling is employed. Thistle can maintain a significant presence in the community only for about 5 years before competing natural vegetation takes over the site. Since thistle is a poor competitor and is generally confined to the moister sites, native vegetation will reclaim the site quickly. On heavily grazed sites dense stands of thistle will persist since the natural vegetation is held in check by livestock. Roads provide seedbeds for isolated or small groups of plants particularly where cut and fill slopes have not revegetated. Invasion into the natural vegetation is normally in conjunction with disturbance associated with grazing, dozer activity or burning. These infestations will die out quickly as the native plant crown closure increases.

Control measures

Mowing was found to an effective method to contain Canada thistle. Mowing should be done at bloom stage or repeatedly to be most effective. Repeated mowing will weaken surviving stems and prevent seeding. Shallow cultivation of the soil breaks up the root system but does not eliminate an infestation unless repeated regularly about every 21 days. Competitive crops, especially

alfalfa and forage grasses, have been used to contain Canada thistle. Alfalfa, with mowing twice each year, reduced the count of Canada thistle to 14 percent of the original figure after 1 year and to zero after 4 years.

A large number of insects have been reported to infest Canada thistle in its natural environment. Unfortunately none of the native North American insects cause sufficient damage to contain the thistle (Moore 1975, Hodgson 1968). There is some promise of biological control with studies presently under way (Peschken 1979). The rust pathogen Puccinia obtegens has caused limited localized epidemics which eliminated thistle in a single season. Systemic infections cause stunted plants which rarely flower. The rusts, however, are very specific by ecotype. Field observations in Montana show that patches of thistle commonly contain one or occasionally two ecotypes therefore a virulent pathogen of an ecotype could contain on entire patch (Turner 1981). Gall flies Urophora cardui have some effect on plants normally in areas shaded by trees. An average of 13 galls per shoot does not reduce vigor of the thistles growing in absence of competition (Monnig 1986, Peschken 1982, Lalonde 1984). This fly is established on at least one site in Montana. A stem boring beetle Ceutorhynchus litura has been introduced on several sites in Montana. Although the beetle does not affect the plant, various other pathogens are provided access into the plant, and 95 percent of the attacked plants may not survive the winter (Monnig 1986).

Thistle is most susceptible to herbicides at bud stage which apparently corresponds to an increase in root carbohydrate content (Sosebee 1983). It is a problem to obtain good control because of the limited movement of the herbicide to the roots in large enough quanties to kill the roots (Baradari 1980). O'Sullivan obtained excellent control of topgrowth using 3,6-dichloropicolinic acid (O'Sullivan 1984).

A strategy of containment through the reduction of sites suitable for its survival is recommended for Canada thistle. Thistle is considered a low risk weed in most forest communities (see Appendix A).

Musk Thistle - Carduus nutans

Characteristics

Musk thistle is a biennial forb and a member of the sunflower family. Musk thistle may also behave as an annual or winter annual. Stems reach a height of 2-5 feet and produce a large flat, solitary, nodding purple flower. It prefers moist, alluvial soils, but it can grow on upland sites. It is generally found on roadsides or waste areas. It is most abundant in moderately grazed pastures, hay fields, grassy roadsides or high, dry ridges and hillsides where limestone or dolomite bedrock are less than 6 feet below the surface. Plants may be rare or infrequent where bedrock is deeper (Lacey & Lacey 1985, McCarty 1982, McCarty & Gorz 1980, Striekey 1971, Feldman 1968). One study showed that 100 percent of the soil samples taken from musk thistle sites gave a slightly alkaline reaction (ph 7.1 - 7.3) (Striekey 1971). The plant is dependent on seed for reproduction. Plant competition, drought and low fertility were found to affect emergence and development (Lacefield 1970). There is apparently a dormancy mechanism operative in some conditions. Because the achenes are not

readily released but remain enclosed in the dried head, natural expansion of the plant's local range is slow. One study of wind dissemination showed that with wind speeds up to 18.4 feet per second, less than 1 percent of the seeds were blown further than 328 feet and most were deposited within 164 feet of the point of release. Over 80 percent of the seed were deposited within 131 feet of the parent causing clumped distribution of rosettes. This results in a high level of intraspecific competition among seedlings (Smith 1984). After emergence the seedlings develop into a rosette stage and overwinter in this form. Bolting begins in the spring and continues until August. Flowering may begin in May or June and about 425 heads per plant may develop (Lacefield 1970). Terminal heads flower first followed in order by primary heads of successive branches toward the base. The amount of branching is a response to crowding, competition, fertility and moisture. Terminal heads produce 1000 seed/head with other heads about 800 seed/head. In excess of 8,000 seed/plant were developed (McCarty 1982). Other studies showed about 625-656 seeds/head (McCarty & Lamp 1982).

In a study of invasion into a pasture it was determined that there was a positive correlation between the number of seedlings and herbage cover. A brome grass meadow is more favorable for invasion than other grass communities because of its open canopy which provides enough light for thistle seedlings at ground level. It generally does better in cool season pastures compared to warm season. Its competitive ability is a function of light and moisture and it is also favored by grazing (Feldman 1968). Feldman (1968) also found that establishment is poor in pastures with vigorous stands of grass compared to bare soil. Thistle plants grown in the absence of competition or on fertile soils grew larger and produced more heads than those grown with competition or on less fertile soils (Lacefield 1970).

Results of field review and analysis

Very few observations of musk thistle were made during the study. Its apparent affinity for limestone derived soils and inability to compete well with other vegetation limits its success in invading most forest environments. Unless grazing or some other impact is present, musk thistle has a difficult time in becoming established.

Two locations of musk thistle were studied on the Lolo Forest. In the Blue Mountain area a small 1/4 acre patch was noted in an area disturbed by ground squirrels and moderate cattle grazing. It is located in a Douglas-fir/ pinegrass-pinegrass (Psme/Caru-Caru) habitat type at 5920 feet elevation. The second location is in the Rattlesnake National Recreation Area. A parcel of ground that was recently acquired has musk thistle present in the vicinity of the building site.

Musk thistle does not do well on dry range land so many of our sites considered to be high risk for other weeds are not suitable for it. On cooler north slopes which are more suitable for musk thistle, restricted sunlight caused by the denser vegetation prevent invasion unless a major disturbance factor keeps the area free of competing vegetation.

Management implications

Musk thistle poses a very low threat to National Forest Land. Other than some minor inconvenience to recreation users, populations are so small and scattered they have limited impact on management. When properly managed, forest sites are maintained in a condition in which musk thistle cannot compete.

All habitat types are rated low or very low to the threat of musk thistle establishment. (See Appendix A)

Control measures

Musk thistle is dependent for its establishment and regeneration on seed production in the immediate area as seed does not travel far. Containment and eventual eradication can be achieved readily by mowing or cutting the flower stalk at full flower. Viable seed per plant dropped from 1029 to 3 with mowing. Care must be taken not to mow too early as the plant will recover and produce a normal seed crop. If done at the proper time resprouting is very rare and virtually all the seed is destroyed. Mowing was better than herbicides in reducing the number of viable seed at all levels of treatment (McCarty & Hatting 1974). Mowing can occur from anthesis (full flower) to about 5 days after and still prevent seed production. If 11 days passed between anthesis and mowing, seed production was the same as the control. This study occurred under cool and moist conditions which slowed maturation. Warmer temperatures may shorten this timeframe. There apparently is a limited seed bank in the soil and within two seasons a population can be eliminated.

The weevil Rhinocyllus conicus is relatively effective in reducing seed production and has proven helpful in containing musk thistle. Seed heads attacked by R. conicus will not release seed properly and the seed will drop to the ground still tightly fixed in the necrotic material. The seeds may germinate but competition among germinating seeds will cause significant seedling mortality (Smith 1984). In pastures with vigorous stands of grass, thistle seed reduction and increased competition among seeds embedded in necrotic heads caused by R. conicus may result in thistle containment (Smith 1984). A site infected by the weevil averaged 28 to 78 percent less seed production over two years (McCarty & Lamp 1982). When more than nine larvae are present in the receptacle the viability of the remaining seed is less than two percent (Monnig 1986). Other studies showed that the weevil preferentially selected early developing heads. A large number of viable seeds are produced at the infected site since many heads bloomed during the third and fourth weeks which were not hit by the weevil (McCarty & Lamp 1982). Fully developed seed still germinated well (96-99%) and were not affected by date of bloom. This weevil is established throughout Montana.

Work on a rust may be successful in the near future. Studies of the rust fungus Puccinia carduorum have shown musk thistle to be highly susceptible. Unfortunately, globe artichoke is also susceptible and therefore the rust cannot be used (Politis 1984).

Treatment of musk thistle with 2,4-D at late-bud to early-bloom stage of the primary heads prevented formation of viable seeds without adversely affecting

the weevil development (Trumble 1979). Herbicide control of musk thistle is most effective when the plants are seedlings or are growing actively as rosettes (McCarty & Hatting 1975).

Because of its relative limited occurrence and ease of control, this weed represents a good species to target for eradication.

Goatweed - Hypericum perforatum

Characteristics

Goatweed is a perennial forb in the St. Johnswort family which grows about 3 feet tall and has orange-yellow flowers (Sheperd 1983, Lacey & Lacey 1985). It reproduces by seed and vegetatively by runners from rootstocks (Sheperd 1983). The root system is branched and extends to a considerable depth, with shallow short rootstocks extending out less than a foot from the crown. It is found in meadows, dry pastures, neglected fields and roadsides. Grazing animals do not eat the plant, but it is best distributed by seed adhering to hair of animals particularly sheep. Wind distribution can occur over very short distances. It is an aggressive pioneer species readily spread by seed to sites where some form of disturbance has left sandy or gravelly soils denuded of vegetation. It can produce up to 25,000 seeds/plant.(Clayton 1978, Reed 1970). Once established it can spread vegetatively displacing all useful range species. It is able to persist where it has gained a foothold in spite of competition from native range plants even without continued disturbance. When a site recovers to the point where no unoccupied soil remains, new seedlings are unable to become established; but adults may persist for decades by vegetative reproduction. Grasses are unable to eliminate the weed. Studies on the National Bison Range found significant differences in plant growth by aspect. Generally the plant puts out a new basal rosette in the fall, the previous year rosettes being shed in July to conserve water. The new rosette normally appears in early September in conjunction with the fall rains. On colder exposures (east and northeast) there was a pronounced tendency for rosettes to be delayed and some did not appear until spring. This was significant on east aspects. The basal rosette size tends to decrease with a change in aspect from south to east and increases in elevation and moisture. Goatweed was not found beneath a Douglas-fir canopy or in forest openings on north and northeast aspects which may also be related to temperature (Clayton 1978). In my studies goatweed did occur below a Douglas-fir canopy, but plants were not as robust and flowering was less common. A reduction in the number and size of inflorescences and the number of flowers per plant was associated with an increase in the canopy coverage of competing plants within 4 inches of the base of the weed (Clayton 1978).

Results of field review and analysis

All goatweed infested sites studied had spotty populations within the forest environment. Because of this trait no apparent trends could be determined between environmental factors and the coverage of goatweed on roads or in the general forest environment. Some observations were made, however, which may be useful in controlling this weed. As in all weeds the road shoulder provided the most common location for its occurrence. Although the weed was widely

scattered there were a few places where saturated stands could be found. Even the largest patches evaluated on forest roads were not dense stands and consisted of populations of less than 100 stalks. Plants on roads were found in a variety of habitat types. The highest elevation noted on the Flathead Forest was about 6200 feet in a subalpine fir/beargrass-huckleberry (Abla/Xete-Vagl) habitat type and on a similar type at 6100 feet on the Bitterroot Forest. It could not be determined if this represented an upper elevational limit or if the plant was in the process of moving up from a lower source.

Where goatweed was found outside the road prism in a forest environment, it was usually associated with disturbance from logging, grazing or fire. Major stands were on old skid trails or landings. Of the 22 plots taken which contained goatweed, none were on north aspects and 2 were on northeast aspects. This supports the findings of the Bison Range study.

Goatweed seems to outcompete knapweed in a grass community but is not as competitive in a forest environment. It competes well with snowberry but does poorly under thimbleberry. While it was not possible to develop any correlations between crown canopy coverage and the amount of goatweed, this failure may be caused by the limited and spotty nature of the stands studied. It is not very competitive under dense canopies. Once established, it is able to persist even after the natural vegetation returns to predisturbance levels.

Management implications

Goatweed poses a major threat to the grass communities on all Forests. This is particularly a problem on the drier sites or heavily grazed areas. While it does not appear that goatweed will be competitive in a forest environment, it can persist once established and may provide a seed source for future movements into recently logged stands.

Control measures

Early Australian work studied effects of mowing, burning, and plowing. Mowing and plowing frequently made matters worse. Mowing favors the weed over the adjacent grasses while plowing was unsuccessful because of fragmenting the woody rhizome. Pulling was unsuccessful for the same reason. Burning apparently has limited impact on goatweed.

The goatweed beetle introduced from Europe has been highly successful in eliminating goatweed from many areas; although a number of sites have been avoided by the beetle. Plants in shade (beneath trees) are relatively safe from attack. Because plants in shade have a tendency to reproduce vegetatively, it is more difficult for the beetle to kill them. Beetles were also found to avoid steep south-facing hillsides, sheet-eroding slopes and grassland areas disturbed by ground squirrels (up to 50 percent bare ground). Areas adjacent to ant nests provided safe areas for goatweed because ants eat the beetles. Basal rosettes do not form on cool aspects in the fall resulting in a lack of beetle activity because of the need for wintering in the rosette (Clayton 1978). Similar problems have been found in Australia where part of the reason for failure of Chrysolina spp. to control goatweed is that they are

out-of-phase with the environment. Control has been very successful where the climate is near Mediterranean. The areas where the weed remains a problem in Australia do not have a true Mediterranean climate (Delfosse 1980). In Montana the beetle has lost some of its effectiveness because of a change in its life cycle. Plants on cool aspects which fail to produce basal leaves during the fall escape being oviposited upon and therefore are immune to this form of control (Clayton 1978). A number of other arthropods are under study to attack goatweed in these environments. Apparently natural enemies are available to contain goatweed in shaded areas since it is extremely difficult to find it there in Europe (Delfosse 1980). A gall midge, Zeuxidiplosis giardi has been successful in Hawaii and South Africa in damp, shaded situations (Delfosse 1980). It has been established in several locations in Montana (Monnig 1986). A defoliating moth Anaitis plaigata has done well in Canada. It can tolerate dry climates and should do well in Montana (Monnig 1986).

Spot spraying with 2,4-D ester may be successful on small isolated populations (Lacey & Lacey 1985).

Contrary to most noxious weeds, a good biological control is available in the form of the goatweed beetle. While the beetle is less effective under a canopy, partially logged or clearcut stands can be favorable to their growth on the proper aspect. Beetles are readily available on the bison range and are easy to collect. While outplantings have been conducted for years, success has been variable. If, however, environmental factors are evaluated and a systematic program developed which includes follow-up plantings, a low cost effective control program can be implemented. Other species of insects have promise and should be added when they are approved. It appears reasonable to assume that goatweed can be controlled with information at hand on the three Forests for a reasonable cost.

I recommend a control program emphasizing a containment strategy be implemented.

Houndstongue - Cynoglossum officinale

Characteristics

It is a biennial forb in the borage family which produces a stalk 8 to 30 inches tall with small purple or pinkish flowers. It may also act as a short lived perennial (Breemen 1984). Houndstongue prefers soils with a high nitrate level which apparently affects germination success. Calcareous sandy soils are more favorable than acid sandy soils. In the Netherlands the species is commonly found on calcareous coastal dunes where it prefers nitrogen-rich places. A typical environment is formed by open spots in scrub. The superficial soil layer in this environment is often loose and disturbed by animals, which may be regarded as favoring mineralization and nitrification. The species is absent on acid coastal dunes and on acid sandy soils of the interior part of the country; it does not occur on clay or peat soils (Freijsen 1980). Germination rates on calcareous dune sand are 57 percent while acid dune sand ranged from 15 to 23 percent. Germination rates on high nitrate soils are 80 to 85 percent while low nitrate soils have a 35 percent rate. Maximum seed germination occurs at 32-50 degrees with 12 percent soil

moisture. Light response proved different for seeds from different populations. Highest germination occurs at 0.4 inches in depth. Studies on Dutch sand dunes indicated houndstongue has a wide ecological amplitude. Seeds can germinate in the fall, and an early frost period can be disastrous for young seedlings. It has the ability to germinate in darkness and at low temperatures and is adapted for colonizing vegetation gaps created by seasonally predictable change and mortality in the vegetation (Breemen 1984). It is slow to germinate but apparently has little carry-over in the soil making the plant dependent on current flowering for new seed. The first year is spent as a rosette which is resistant to drought. No plants flowered the first year, but some waited until the third year after which they died. Occasionally some plants flowered a second time (Boorman 1984). Seeds took nearly 70 days to ripen after flowers opened. Seeds have barbs which attach to clothing, hair and wool. Although the seeds adhere strongly to woven fabrics, sheep wool and cattle and horse hair, they are scarcely held by the fine fur of rabbits and the hair of deer and elk. It produces about 2500 seeds/plant which are animal dispersed. New plants are also found within a small radius around existing plants. Seeds are inherently dormant; most germination is in late winter and early spring after a period of cold (Breemen 1984). They need a period of low temperature to break dormancy (Boorman 1984). A 6-week moist, chilling period can break dormancy. Seeds can persist on the soil surface and on the inflorescences; the latter seed bank may last for 2 years. Otherwise it does not have a persistent seed bank. Houndstongue's strategy is to reduce mortality risks connected with germination and survival of seeds in space as well as in time. It is expected to live in a habitat predictable in space and time (Breemen 1984).

Results of field review and analysis

There is a very strong relation between cattle grazing and the location and amount of houndstongue. All existing populations studied were found where moderate to heavy grazing is ongoing or had occurred in the recent past. In areas of light or no grazing houndstongue was found only as an accidental or small group of plants. Roads provide a favorable seed bed and represented the major acreage where houndstongue is found. No correlations were noted among environmental factors or other species and the occurrence of houndstongue on roads or disturbed areas.

Moderate to heavy infestations were found on all three Forests in a number of site conditions. A major infestation is located on the Bitterroot Forest at the head of Coffee Gulch, Brennan Creek, and Newton Gulch in a ponderosa pine/Idaho fescue (Pipo/Feid) habitat type. Cattle in this area had mats of seed on their faces and body. Plants were located in groups over the entire area with heavy concentrations on the shoulder of the road, loafing areas under heavy shade, disturbed areas from cattle use, areas associated with burn piles and skid trails and rocky areas with limited vegetation. The riparian zone has been converted to a blue-grass community through cattle grazing and timber harvest. These areas are receiving heavy use by cattle, and houndstongue is well established.

A clearcut on the Flathead Forest in a Douglas-fir/pinegrass-ponderosa pine (Psme/Caru-Pipo) habitat type represents another condition where with cattle

use and site disturbance a light to moderate infestation of houndstongue has become established.

A third site located on Blue Mountain on the Lolo Forest represents an infestation that has become established in an area with heavy ground squirrel activity and light grazing. It is in a Douglas-fir/elk sedge (Psme/Cage) habitat type that has limited man-caused disturbance.

In addition to roads, burn piles are also a major area of establishment for houndstongue. Riparian zones appeared to have more houndstongue than the general forest area, but this may be caused by the concentration of cattle use there. While plants grew under heavy competition from shrubs their establishment was dependent on some disturbance.

Management implications

Houndstongue does not pose the problem of saturating a site as many of the other weeds. Even in heavy stands the impact on the forage available is limited. It is a major negative factor to recreational use and can be a problem for cattle causing them discomfort in feeding. Once attached the seed is carried back to the home range spreading the seed onto private land.

The spread of houndstongue is limited by the carrier and the availability of disturbed sites for seed establishment. Active grazing is critical for the maintenance of the weed in most of our communities.

Apparently there is an upper limit to successful regeneration. Habitat types found above subalpine fir/beargrass (Abla/Xete) may be unsuitable for houndstongue because of the short growing season and its long seed maturity requirement. Houndstongue is adaptable to a variety of sites at lower elevations and is found in many of the warmer habitat types along roads. Establishment off roads is restricted to disturbed sites. The ponderosa pine series and the Douglas-fir grass types appear to be more susceptible to establishment than the remainder of the types. Limited calcareous soils may also be a factor in the spread of houndstongue over many parts of the Forests. (See Appendix A)

Control measures

The occurrence and spread of houndstongue is strongly associated with livestock use. By controlling cattle, houndstongue can be contained. Houndstongue does not maintain a seed bank in the soil which allows for relatively rapid elimination of the plant from an area when control measures are undertaken.

Removal of the flowering stalk has a significant impact on seed production. Topping the plant when flowering can result in a 10-fold reduction in seed production. Treatment must cover at least 2 years since the plant is a biannual. One study showed a seed reduction from 1508 to 249 seeds/plant with topping in mid-June. Many of these remaining seeds came from laterals developed by the plant (Boorman 1984). Mowing several times may eliminate almost all of the seed production (Muenscher 1955). While there was no mention of the effect of burning on the weed in the literature, this may be a useful

tool. Much of the seed bank is found on old plant stalks and a fire could eliminate much of this source through late fall burning. Houndstongue can be killed in the first year by spraying 2,4-D about mid-June. Second-year plants are much less susceptible. Spraying must be conducted several years in a row to be effective (Lacey & Lacey 1985).

No references were found on biological controls for this weed.

Removing cattle from heavily infested sites will greatly aid in the treatment. Reducing the number of disturbed sites in an infested area will have a marked impact on the success of the plant. The impact of burn piles can be reduced by waiting until soil moisture recharge has occurred in the fall. This will lessen the recovery time of the native plants on these sites. If logging is anticipated on the drier types, an assessment of removing cattle for a period to assure recovery of the disturbed sites will reduce the likelihood of spread. Riparian areas that have been converted to bluegrass bottoms through cattle use represent a major problem area in houndstongue treatment. Allowing these to recover to their natural vegetation will eliminate much of the risk and extent of houndstongue.

Based on the findings of this study I recommend the management strategy for houndstongue should be eradication.

Leafy Spurge - Euphorbia esula

Characteristics

It is a long-lived perennial plant, native to Europe and Asia, that was introduced into the United States in 1827 (Ebke 1983). It normally grows 2 to 3 feet tall from a somewhat woody crown that is below the soil surface. Each crown area produces several upright stems giving the plant a clump-like appearance. The leaves have a characteristic bluish-green color but turn yellow or reddish-orange in the fall. All parts of the plant contain a milky juice. It is found mainly in pastures, rangeland, waste areas, and along roadsides. The plant occasionally occurs in cultivated areas (Eberlein 1982). Infestations are dominant on lowland/bottomland range site/topographical positions (_____ 1983).

The species often flourishes in open-grown oak woods and has shown an ability to become established readily in competition with shrubs and open stands of aspen. In Saskatchewan it has been found in almost every terrestrial habitat with the exception of coniferous forest (Selleck 1962). It has been found to spread in native ungrazed grassland (Stipa-Agropyron), and brome grass is not able to compete effectively against the weed. Crested wheatgrass is no more effective than brome in reducing density of spurge but is capable of limiting the rate of increase of sparse stands (Best 1980).

The root system is extensive and consists of numerous coarse and fine roots which occupy a large volume of soil. They may go to a depth of 15 feet or more. They have numerous buds capable of producing new shoots. The root system contains a large nutrient reserve capable of sustaining the plant for years (Eberlein 1982). Roots have the ability to produce vegetative shoots for

5 successive years from a depth of 3 feet after the major portion of the root system is removed (_____ 1979).

Stems originating from roots begin growth in late April, making leafy spurge one of the first plants to emerge in the spring. Its early emergence and accelerated growth at high soil temperatures result in adaptation to a wide soil temperature range making it very competitive not only early but during the entire season (Morrow 1979). Leafy spurge seeds germinate in late May and early June, but seeds can germinate throughout the growing season. Seedlings do not flower during the first year (Eberlein 1982). Germination is best at 86 degrees and failed at temperatures of 113 degrees. Only 1 of 400 seeds germinated at temperatures between 46 to 54 degrees. Seed can emerge from a variety of depths in the soil but did best at 0.5 to 2 inches. Seedling emergence and survival was eight times greater on a cultivated area than under a patch of western snowberry Symphoricarpos occidentialis which indicates that seedling survival was severely restricted but not prevented by competition (_____ 1983). I would assume that the more common snowberry Symphoricarpos alba which normally is about half the size of western snowberry would be less effective in restricting leafy spurge. Leafy spurge seedlings have a remarkable capacity for vegetative reproduction and can vegetatively reproduce within 7 to 10 days after emergence. Leafy spurge patches may reach a density of more than 200 stems per square yard in sandy soils and even higher densities in heavy clay soil. It usually spreads vegetatively from 1 to 3 feet per year and forms dense patches which crowd out other plants by shading and competing for moisture and nutrients (Eberlein 1982). It apparently is sensitive to nitrogen deficiency (Best 1980).

It produces a flat-topped cluster of yellowish-green petal-like structures called bracts which bear the true spurge flowers. The bracts appear in late May and early June, but the true flowering does not occur until mid-June (Eberlein 1982). Ripe seed is produced 20 to 30 days after female flowers appear (Lacey & Lacey 1985). Seeds are borne in a pod which burst when mature, scattering seeds up to 15 feet from the parent plant. An average of 140 seeds is produced per stem, and seeds may remain viable in the soil up to eight years. When light is limiting, the percent of flowering shoots decreased. Nonflowering shoots survive in aspen groves, but development of inflorescences is inhibited. Leafy spurge flowered at 6fc (foot candle) and vegetative shoots survived in aspen to reading below 3fc. In open areas reading were 60fc. Leafy spurge in an oak woods produced seed at 10fc compared with 65fc in the open. The density of leafy spurge was maintained to 4fc but few shoots were present at 2fc. A tall dense stand of woody plants may limit lateral extension of spurge and where light is severely limiting may prevent its establishment (Selleck 1962). Best et al (1980) also found light a limiting factor for flowering and for shoot survival. Numbers of flowering shoots decrease under canopies of aspen, and vegetative shoots will not survive in light of less than 2-3fc.

The seed has the ability to float and germinate in water (Selleck 1962) and can survive flooding for extended periods. Wild and domestic animals, birds and insects are agents of seed dispersal. Mourning doves (Zenaida macroura) will feed exclusively on the seed when available and have the ability to destroy a large amount of seed (Selleck 1962). Sharp-tailed grouse (Pedioecetes

phasianellus) and field sparrows (Spizella pusilla) also make use of the seed, and birds are considered primary disseminators (_____ 1983).

White milky latex is present in all parts of the plant which can produce blisters and dermatitis in both man and cattle (Lacey & Lacey 1985). Allelopathic reactions were noted on tomatoes when soil samples from moderate to high spurge densities were incorporated into their growing medium. Reductions were also noted for quackgrass (Agropyron repens) and common ragweed (Ambrosia artenisufolia) where spurge had high densities (Steenhagen 1979).

Results of field review and analysis

While many infestations occur on private lands adjacent to Forest Service ownership, they are generally in grass communities. To date there are limited occurrences within forest communities. Three were reviewed in the field on the Lolo Forest in Nemote Creek, Blue Mountain and in the Rattlesnake National Recreation Area.

The population in Blue mountain is principally on a bluebunch wheatgrass/Idaho fescue grass type with scattered ponderosa pine. It is on a southwest exposure and the community is saturated with knapweed. On the locations where leafy spurge is present knapweed is limited to a few scattered plants. Under the low hanging dense ponderosa pine canopies there is no knapweed but leafy spurge did occur. There has been no activity in the immediate area for some time other than grazing, and cattle or birds may have been the vector which brought the leafy spurge into the area. Past grazing practices as well as competition with knapweed have reduced the grass component to a few scattered plants.

The Nemote creek site is located in the riparian zone along the creek and on a north slope. Leafy spurge is found on a dry gravelly terrace in the riparian zone. This is a Douglas-fir/pinegrass-kinnikinnick (Psme/Caru-Aruv) habitat type that has been logged and thinned. The spurge is confined to the skid trails with only an occasional plant in the undisturbed area. A Douglas-fir/ninebark (Psme/Phma) habitat type is located on the north slope which has been logged and grazed. Leafy spurge is found under the Douglas-fir canopy only on disturbed areas. On the road up to Stark Mountain Lookout there is a patch located in a Psme/Caru-Aruv and Douglas-fir/Idaho fescue (Psme/Feid) habitat types. In the first it is located only on the skid trails with an occasional plant in the undisturbed type while the fescue type has plants distributed both in the disturbed and undisturbed areas.

The Rattlesnake patch is located in Sawmill Gulch on lands just acquired from private holdings. The area has received heavy grazing in the past. It is located in a Douglas-fir/ninebark-pinegrass (Psme/Phma-Caru) habitat type that contains a stand of ponderosa pine and Douglas-fir about 70 years of age. The stand is moderately open with a dense shrub component. Leafy spurge was found along the road and some patches extended into the stand. It was observed growing under ninebark shrubs but was generally lax in appearance and was not flowering.

There is limited information available on which to predict how successful leafy spurge will be in a forest environment. While it can grow under a dense tree

or shrub coverage it does not flower, which may influence its rate of spread. It still can increase its area by vegetative means but it is unclear if it will gain the density necessary to impact native vegetation.

Other areas of infestation occur in the study area but were not investigated. Presently known infestations are confined to the lower elevations. This may simply reflect a normal establishment pattern and with time it may move up slope into the general forest zone.

Management implications

To date leafy spurge has had limited impact on forest communities. However, it poses one of the most serious threats in the future. If knapweed is considered a problem to eradicate, leafy spurge will be many times worse because of its huge food reserves in the roots, its ability to survive under dense shade and its resistance to herbicides. It does not appear to be particularly aggressive in invading undisturbed areas but once established is extremely difficult to eradicate.

Control measures

Presently it may be impossible to achieve long-term control of leafy spurge. Small patches of young leafy spurge can be eradicated with a persistent herbicide. A combination of chemical and cultural treatments such as cultivation, cropping and grazing may be necessary to stop the spread of leafy spurge (Lacey & Fay 1985). Roots scattered in the field by cultivation produce new plants in addition to those established by seeds. Pieces of roots as small as 0.5 inch long and 0.1 inch in diameter will produce new roots. Pieces of root can survive 2 or 3 hours of drying in the hot sun. Eberlein (1982) found that a 2,4-D oil soluble or water soluble amine formulations may be used to contain leafy spurge top growth under trees but will have limited effect on elimination of the plant, and Bybee (1976) found the density of a spurge stand back to pretreatment levels a year after discontinuation of spraying. Glyphosate will give 80 to 90 percent top kill if applied from mid-August to mid-September. A follow-up treatment between mid-June and mid-July of the next year with 2,4-D is necessary to prevent seedling reinfestation. Follow-up treatment will be necessary for a number of years to kill new seedling. An extra 10 to 15 feet around leafy spurge patches should be treated to contain spreading roots and seedlings around the established stand (Eberlein 1982). Leafy spurge cannot be eradicated with a single herbicide treatment and in fact may take 5 to 10 consecutive years of treatment to eradicate an established stand (Lym 1985). Well established stands are extremely difficult to eliminate even with long-term treatment.

Studies being conducted on the Glacier National Park indicate the plant can be contained with mowing once a year. After mowing the plant does not regrow well and will not flower. Burning on the other hand stimulates the growth of leafy spurge resulting in substantial growth response.

Cultivation with a duckfoot cultivator, tilling 4 inches deep, can be used for containment where possible. Treatments must begin early in the spring, 2 to 4 weeks after the weed emerges. Cultivating every 3 weeks until the soil freezes

is required for two growing seasons to attempt eradication of the patch. Smooth brome (Bromus inermis) has been effective in reducing leafy spurge density when 2,4-D was applied or the area cultivated prior to planting (Lacey & Fay 1985, 1984). When grown in a perennial grass sod of crested wheatgrass (Agropyron desirtorum) and smooth brome, no plants flowered or produced additional shoots. An early emerging crop might suppress spurge by utilizing available moisture in the growing season (Morrow 1979).

Sheep grazing will not eradicate the weed but will reduce its density and limit spread. Grazing should be started early in the spring when the plants are 2 to 6 inches tall. Grazing should be conducted to prevent leafy spurge from producing seed and allow desirable forage plants to regain vigor (Lacey & Kott 1984). No significant difference in weight gain was noted in ewes who consumed up to 50 percent of their diet as leafy spurge (Landgraf 1984). Continuous sheep grazing for 8 years prevented annual seed set and reduced the size of the soil seed bank from greater than 3,500 to 15 seeds per square yard, greatly reducing the chance of reestablishment from seed. With sheep grazing, density of spurge remained high for 3 years after which a drastic reduction in shoot density occurred. After 8 years, 4 to 8 shoots per square yard were still growing from perennial rootstocks (Bowes 1978). After 13 years of sheep grazing a pasture with about 100 stems per square yard of leafy spurge has now about 5 percent spurge and the weed was only 2 or 3 inches tall in August (Lacey & Lacey 1985). Observations indicate that if it is not permitted to develop beyond a height of about 2 inches throughout the growing period, the food supply in the roots will be exhausted within 3 years resulting in death of the plant (Selleck 1962). Shoots developing after top removal by mowing or grazing in the early part of the growing season produce inflorescences only on lateral branches (Selleck 1962). Mowing leafy spurge resulted in good recovery of native grasses. Use of black plastic has been tried along with burning. Results of covering are not available. Burning had a stimulating effect on leafy spurge and resulted in increased stand density. Some success has been had with grazing goats in containing leafy spurge. (pers. com. Gary Gregory GNP)

Biological control with the use of insects and/or plant disease-causing organisms is just beginning. The leafy spurge hawkmoth, Hyles euphorbiae which feeds on the leaves has been established on two locations. The results to date have shown minimal effect on the leafy spurge population (Monnig 1986). A root and stem boring beetle, Oberea erythrocephala has been released and has the potential for damaging the stem and root system and reducing seed production. A number of other insects and plant diseases are being evaluated as it will require a complex of insects and plant diseases which attack various parts of the plant to provide enough stress to attain acceptable containment (Lacey 1985, Forwood 1980, Monnig 1986). Spurge is contained naturally in Europe by indigenous insect predators; however, attempts to utilize these predators in North America have proven unsuccessful. Data support the suggestion that North American leafy spurge may be an interspecies hybred which makes it less susceptible to insect attack (Manners 1974, Ebke 1983, Best 1980). A rust, Alternaria tenuissima which is a part of the northern Great Plains ecosystem, can attack leafy spurge and may provide some containment (Krupinsky 1983). Although plants were not completely killed with one inoculation, the tops of the shoot systems were killed thus preventing seed production. Infected plants

appeared less vigorous and should have a reduced competitive ability.

Once established there are few options for eradication in the forest environment. Grazing by sheep or mowing may be viable treatments and provide containment of the weed, but neither treatment is effective in eliminating the plant. Additionally other considerations may preclude their use. Available herbicides may not be suitable for use other than as a delaying tactic and may be restricted because of the impact on tree growth. The only reasonable course of action available at this time is to support research on biological controls.

I recommend that the Forests monitor high risk areas for new infestations and implement a containment strategy.

Tansy - Tanacetum vulgare

Characteristics

It is a perennial forb in the sunflower family that spreads mainly by seed but may also spread by rhizomes. Plants have a bush-like appearance as the plants tend to grow together. They are about 3 feet tall and have small, yellow flowers which form flat-topped clusters. The leaves are very aromatic when bruised. It is normally associated with stream banks and irrigation canals where it may form dense colonies. It is usually found in areas that receive about 17 inches of precipitation (Crockett 1977, Muenscher 1955, Lacey & Lacey 1985). The literature reviewed provided little detail on seed viability or other information relating to the life cycle of the plant.

Results of field review and analysis

The weed was found to occur in two conditions on the three Forests. Dense stands are found along the major river drainages. The largest of these was located on the Bitterroot Forest on an isolated tract adjacent to the Ravalli County Wildlife Refuge. This area is in the major flood plain of the Bitterroot River and is bisected by numerous old channels. Some of these apparently carry water during high water periods. The habitat type is identified as a gallery forest by Pfister (1977). A mature stand of cottonwood and ponderosa pine are found in the overstory. Major understory associates include wood rose (Rosa spp.), snowberry (Symphoricarpos alba), bluegrass (Poa spp.), sedge (Carex spp.), bedstraw (Galium triflorum), and Missouri goldenrod (Solidago missouriensis).

No correlations could be found between the coverage of tansy and the presence of other plant species or other environmental factors. Crown coverage of the overstory did not appear to affect tansy survival; however, areas with no overstory had stands of tansy with 100 percent coverage of the site and were almost impossible to traverse. Dense tangles of old and new shoots were encountered which could impede wildlife movement through the area. While a correlation was noted between the height of tansy and the height of common aster, it is unclear at this time if this information is significant in predicting potential impacts in the community. Tansy did not occupy wet areas found in the old sloughs or stream channels. Because of its dominance in the flood zone, it may be assumed that seed dispersal may be aided by water

transport and the plants must be tolerant of periodic flooding.

The second condition was found along smaller streams and road shoulders. Generally along roads the plant is confined to a few stalks, whereas upwards of 50 stalks or more may be found along the streams. These populations are small and isolated. A wide range of aspects and elevations were noted and no upper elevational limit could be determined. Isolated plant clumps were found from the valley floor to as high as 7250 feet on a road shoulder in a subalpine fir/beargrass (Abla/Xete) habitat type on the Bitterroot Forest. Other than in the major stream bottoms, I did not find any plants occurring off the road shoulders. It is unclear if this distribution pattern is a result of the plants' inability to compete with natural plant communities or an indication of an expanding population. Its best growth, however, was associated with the riparian zone particularly those with moderate to heavy grazing.

Management implications

The greatest risk to management is related to the major stream riparian zones. Dense stands of tansy can develop which will reduce other vegetation and may make wildlife use difficult. There is limited federal ownership in the major valley bottoms and therefore the weed is not considered a major problem. This loss of natural forage may be of concern in some specific locations and may have a direct impact on white-tail deer use.

Occasional plants along roads showed signs of grazing. Both flower heads and leaves were utilized. No evidence of grazing could be found on the plants in the riparian zone. No reference to livestock use was found in the literature.

No information could be found in the literature on biological controls.

Based on information to date, I feel that this plant represents a low risk to management but at the same time, one that should be treated aggressively since its distribution is still somewhat limited.

Control measures

Control measures along our roads can easily be initiated. Isolated clumps can be pulled or dug out because of its limited ability to resprout. The plant is easily identified and control actions can provide a high degree of containment.

Large stands in the major riparian zones will be more difficult to treat because of the extent of the stands. In locations that can be mowed containment can be achieved with about 2 mowings during the growth period. Burning does not seem effective in controlling tansy but may be helpful in reducing the accumulation of dead stalks and facilitate the application of other treatments. Cultivation has also been effective in reducing the weed. This treatment can be by disking or with the use of a cultivator. A follow-up treatment of pulling new plants can provide a high degree of treatment success (Crockett 1977, Lacey & Lacey 1985). In large infestations that cannot be cultivated or mowed because of site conditions, herbicides may have to be considered. Because of the location of these plants this treatment poses some high environmental risks and should be considered only when other treatments

fail or cannot be applied.

The most effective herbicide for treatment is Tordon. Spraying before the plant reaches bud stage provides the best control.

I propose a containment strategy be implemented on the larger patches in our riparian zones and an eradication program be implemented along our forest roads.

Dalmation Toadflax - Linaria dalmatica

Characteristics

It is a perennial forb of the snapdragon family which spreads by creeping roots and seed (Alex 1962). Plants are about 2 feet tall, pale green and have very showy, yellow flowers. It is an escaped ornamental usually found on rangeland, mountain meadows and waste areas such as roadsides with sandy or gravelly soils. It is commonly found in a Mediterranean climate which is characterized by high autumn and winter precipitation with a secondary maximum in the spring followed by a summer minimum. Areas of major infestation in Washington are in the ponderosa pine type and generally confined to south slopes. There is evidence which suggests that the plant can become established in the native community and remain there in a subdued role until the native plants are reduced or destroyed. Examples have been found where it has entered range communities which have not been grazed for many years (Bogavac 1974).

Researchers feel number of sunny days and the insolation sum are of key importance in determining the range in Yugoslavia. Dense populations are found in regions characterized by a high insolation sum. It grows chiefly on quasiskeletal or skeletal, calcareous soils on a limestone substratum. Toadflax responds well to fertilizer treatment in grass seed production areas (Lange 1958). It most often inhabits open areas usually with a rather sparse vegetation on steep, bare stony slopes besides roads (Bogavac 1974).

Dalmation toadflax flowers in June and may continue until the late fall. It produces numerous seeds between July and September. Germination rates vary around 25 to 35 percent with some seed germinating the same season it is produced. It has an extensive root system that enables it to survive adverse soil and climatic conditions. Roots may extend 6 feet or more into the soil with laterals extending up to 12 feet or more (Parker 1974). It produces tillers in the fall which may produce seed the following spring. Buds also can originate on lateral roots producing new top growth. Old established plants form large crowns and may develop as many as 12 to 15 stems at ground level. This type of plant can produce up to 400,000 seeds a year. It will take 2.5 months from flowering to completion of seed maturation. The seed holds viability for up to 10 years and have optimal emergence at a depth of 0.2 to 1 inch. Deeper planted seed germinates but do not emerge (Bogavac 1974). Seed germinates in a temperature interval of 41 to 86 degrees with best germination occurring between 59-77 degrees. Seed exposed to temperatures of 95-104 degrees did not germinate. Wintering in the soil under natural conditions had a stimulative effect on germinability. During May and September, many new sprouts are produced in the root neck area and develop rapidly especially with

removal of the initial flowering stem. Fall shoots are killed by winter cold while older stems with a lignified base retained their vitality and continued to grow next spring. Vegetative propagation plays an important role in its spread while seed plays a limited role because of the many factors which limit development of a proper seed bed. The weed appears to be susceptible to competition from other species. It does not exhibit a particularly high survival or expansion capacity in competition with other plants nor is it able to establish populations of any density on tilled land (Bogavac 1974).

Results of field review and analysis

This species has a limited distribution on the three Forests and is confined primarily to private land in the major valleys. Based on the season length required to mature seed, it probably is not a successful seeder above 5000 feet on the Flathead Forest, 5500 on the Lolo Forest and 6000 feet on the Bitterroot Forest. It apparently requires a high insolation sum and is confined to south slopes. For this reason it is doubtful that it can compete successfully under other than a very open timber canopy.

Management implications

This species is considered a low risk to forest communities and will be of concern principally on the valley floor adjacent to the Bitterroot and Clark Fork Rivers and Flathead Lake. The species will normally be found on range land and have limited occurrence within the forest zone. Appendix A provides a risk rating for the habitat types found in the area.

Control measures

Dalmation toadflax is difficult to control. Plants can be hand pulled, but all lateral roots must be removed to eliminate root buds. A number of insects are potential biological control agents but none have been identified to date (Rizza 1981). Biological controls may be limited by domestic snapdragon which is closely related to dalmation toadflax. Herbicide treatment will not usually provide complete eradication of the weed. The best results have been with Tordon.

The species is limited in the study area and efforts should be directed to eradication. Infestations are generally small and can be treated by a combination of pulling and spot herbicide application. The species can enter stable range communities, and for this reason periodic surveys will be necessary to keep the species in check. A 10-year seed bank can be expected on areas where the plant is found and a long-term, follow-up program will be necessary in areas treated.

OTHER NOXIOUS WEEDS

The following weeds while generally not found on National Forest land may pose a threat for future infestation. These species should be monitored to insure they do not become established, particularly yellowstar thistle. Common toadflax, while present on Forest land, has not been recognized as a serious threat.

Dyers Woad - Isatis tinctoria

Dyers woad is an early season perennial mustard which likes cooler temperatures. It has basal leaves and characterized by decreasing leaf size up the stem. The plant will gain a size of 1 to 3 feet and have a smooth bluish-green color. The upper leaves clasp the stem and have ear-like projections. It has yellow flowers made up of 4 petals and develops a flat seed pod rather than the typical round-heavy seed pod found on native mustards. It is found in the dry lower valleys north of Missoula in limited locations on disturbed sites and is easy to control. Spraying with 2,4-D early in the spring is the common control treatment; however, several years of spraying are needed to eliminate the seed bank (Lacey & Lacey 1985, Lackschewitz 1986). This plant will not normally be found in a forest environment.

White Top - Cardaria draba

It is a creeping perennial which likes cooler temperatures and blooms early in the spring. The leaves are much more uniform then Dyers woad and it has white 4-petaled flowers. The plants are about 10 to 20 inches tall and often lodge with age. The leaves are grayish-green and lance-shaped with the upper leaves clasping the stem. It is found mainly in the Lewiston area but is also common in the main valleys adjacent to the study area where it prefers moist sites. It is normally controlled with 2,4-D ester at early bud stage. The treatment may have to be continued for 2 or 3 years (Lacey & Lacey 1985). This plant does not pose a threat to forest communities.

Common Toadflax - Linaria vulgaris

It has narrow leaves and looks similar to leafy spurge but does not have milky sap and has a showy flower similar to a snapdragon. This plant is well established on many sites in the study area where it is confined to warmer moist to dry sites (Hitchcock 1976, Parker 1974). It has not gained much attention because of its limited size and lack of domination on the infested site. It can reduce the amount of forage on the site and may pose some potential for long-term adverse impacts.

Yellowstar Thistle - Centaurea solstitialis

The stems are winged by the leaves, with the lower leaves toothed or pinnatifid. The flowers are yellow with large spines on the bracts. The leaves and stem are also covered with tangled, woolly hairs. It is not presently known in Montana but it is considered a major threat to the State. A collection was made in the Bitterroot valley a number of years ago but has not been reported since then. It is presently found in Idaho (Hitchcock 1976, Lackschewitz 1986).

Russian Knapweed - Centaurea repens

It is a perennial flat-topped forb that spreads by creeping rootstocks and seed. Plants vary from 1 to 3 feet in height with lavender thistle-like flowers (Lacey & Lacey 1985). Short, stiff hairs cover the leaves and stems.

It differs from spotted knapweed in that it spreads most commonly by deep, scaly, creeping rhizomes, and it is a perennial. It can survive in cultivated fields, pastures, roadsides, waste places, and on rangeland. Roots can penetrate to depths of 8 feet at the end of the first year (French 1983). It is very site specific in its environment and commonly found in river bottoms and high moisture areas. Tordon will control the plant when sprayed in the early-bud stage. It has been found at lower elevations north of Missoula in isolated occurrences (Lackschewitz 1986).

RECOMMENDATIONS

As a result of this study a number of recommendations for weed management have been formulated. These have been categorized into three groups and are presented below. In most cases there are opportunities for weed containment without the use of herbicides. While there is a place for the use of herbicides in a weed control program, large-scale applications to treat weeds such as knapweed may not be realistic from a cost/benefit standpoint or the risk of adverse environmental impacts. Once established, most noxious weeds are extremely difficult to eradicate. While eradication should be a long-term goal, more realistically the best we can do for most noxious weeds with present control options is some level of containment of the population. This concept should be considered in developing an aggressive but realistic weed control program.

General Recommendations

1. Develop and implement a training program to familiarize all Forest personnel with noxious weeds and what they can do to help contain or eradicate them.

2. Actively seek support at the University of Montana and Montana State University to conduct studies to gain knowledge on the autoecological aspects of the major noxious weeds and a better understanding of the weeds' position in a forest community.

3. Establish a working relationship with the newly established APHIS insect dissemination group at Montana State University and other groups working with biological controls.

4. Develop an emphasis item for management to highlight noxious weed control.

5. Actively work with the Regional Office to develop a strong regional approach to weed control and provide coordination with the county weed control boards.

6. Develop a noxious weed plan which provides control strategies for each noxious weed.

7. Initiate a survey of the Forest to determine extent and severity of noxious weed populations for use in determining or modifying control strategies.

Road Management Practices

1. Develop an environmental ethic within Forest employees similar to that exemplified by "can collection" to take action on noxious weeds found along our roads.

2. Use a seed mix for all revegetation work that includes a fast, early growing species such as annual wild rye, crested wheatgrass, or yellow sweetclover to provide a dense vegetation on disturbed sites.

3. Expand the present concept of road maintenance to include treatment as necessary of cut and fill slopes with fertilizer and seed to meet the objective of gaining a vigorous plant community that can resist the invasion of noxious weeds.

4. Consider road closures including administrative travel as a means of noxious weed control in high risk plant communities.

5. Consider using the concept of "adopt a road" to enlist support from civic and volunteer groups to implement road cleaning programs.

6. Work with permittees to assure that stock brought onto the National Forest will be handled in such a manner that weed transport is limited. Practices such as control of feeding prior to planned trips and cleaning animals are examples of these actions.

7. Consider controlling the animal feed brought into the National Forest to that which can meet standards which will minimize the risk of noxious weed introduction.

8. Initiate a "clean" equipment program to reduce the spread of weed seed on high risk areas.

Recommendations for Treatment of Specific Noxious Weeds

Spotted knapweed

I recommend a strategy that would attempt to contain existing infestations and prevent the establishment of new populations as a result of our management activities. To implement this strategy the following recommendations should be considered.

1. Use the knapweed road model (Appendix D) to predict the risk of knapweed infestation on all new road construction. Use the risk rating to determine control measures necessary to reduce the weed invasion risk.

2. Where practical, retain shade on road surfaces by limiting road-side clearing and harvest cutting.

3. Newly constructed roads should be surveyed and all new knapweed plants pulled or spot sprayed annually as a part of road maintenance.

4. Conduct a survey of our existing roads. Those segments that are currently free of knapweed should be treated as new construction.

5. Evaluate the proposed cutting unit as to the risk of knapweed invasion using the models in Appendix A and E.

6. Consider using "clean" equipment for timber harvest in high risk areas where knapweed is not present.

7. Use dozer scarification only where it is the only practical treatment on moderate and high risk areas. This treatment should be carried out only with "clean" equipment in uninfested areas.

8. Silvicultural prescriptions should be directed at maintaining as much shade as possible on site and limiting the amount of soil disturbance to meet regeneration needs. On high risk areas consider using single tree or a light shelterwood harvest method.

9. Evaluate the risk of permitting cattle use after harvest on high risk areas.

10. Consider winter logging on high risk areas where seed is present to reduce the threat of seed transfer to uninfested sites in the stand.

11. Consider seeding non-sod forming grasses to occupy disturbed sites on high risk areas.

12. Actively support the introduction of biological control agents into our present infestations.

Diffuse knapweed

Based on our present knowledge of the distribution of this weed, I recommend that our control effort be eradication. In some locations this objective will require a long-term commitment to follow-up treatments. To implement this strategy the following recommendations should be considered.

1. Consider the use of herbicides for spot applications in the control program.

2. Coordinate efforts with county weed boards to identify infested areas and develop control programs.

3. Consider burning and mowing as viable options in control programs.

4. Introduce biological control agents as they become avaialable.

Canada thistle

Since this is a low risk weed, I recommend a strategy of containment through

the reduction of sites suitable for its survival. The following recommendations should be considered in this strategy:

1. Consider reducing the impact of grazing in riparian zones to permit the areas occupied by bluegrass communities to revert back to the native vegetation.

2. Burn dozer piles when soil moistures are high to reduce the establishment period for native vegetation and the chance of thistle invasion.

3. Consider removing cattle from recently disturbed areas to allow recovery of native vegetation and reduce the period when thistle can find a suitable environment.

4. Control weeds along roads in conjunction with the proposed treatment described under spotted knapweed.

Musk thistle

The control strategy for this weed should be eradication. The following recomendations will assist in implementing this strategy.

1. Consider implementing a program of topping plants during the bloom period to eliminate the seed source.

2. Follow up with periodic checks to insure no plants were overlooked.

3. Introduce the weevil into large musk thistle populations.

Goatweed

A containment strategy should be implemented for this weed. The following recommendations should be considered to implement this strategy.

1. Develop a program of beetle collection and outplanting on goatweed populations.

2. Support research on other biological control agents.

3. Pull isolated plants along roads as part of the proposed treatment for spotted knapweed.

Houndstongue

It is recommended that the strategy for this weed should be eradication. With time the following recommendations will help meet this goal.

1. Consider removing cattle from heavily infested sites to aid in treatment.

2. Where appropriate consider mowing, grazing or spot herbicide treatment

to keep current populations in check.

3. Evaluate cattle use in riparian areas that have been converted to bluegrass communities. Permitting the recovery of natural vegetation will eliminate a significant portion of the presently suitable sites for houndstongue.

4. Use topping, burning, or digging as appropriate on existing populations particularly along roads. Physically removing old seed stalks or burying on site to a depth of about 5 inches will eliminate a major seed source.

Leafy spurge

I recommend a containment strategy on new infestations and containment of old infestations where feasible.

1. Provide financial assistance for development of biological control agents.

2. Where appropriate consider mowing, grazing or spot herbicide treatment to keep current populations in check. Once started, these programs must be continued on an annual basis to maintain containment of the weed.

Tansy

I propose a containment strategy for large infestations in the riparian zone and an eradication program along roads and on limited infestations in the riparian zone.

1. Initiate a program to eliminate populations along forest roads by pulling, digging or the spot application of herbicides.

2. Evaluate riparian infestations and develop strategies to control and/or eradicate the plant.

Dalmation toadflax

The control strategy for this weed should be eradication recognizing that it will require a long-term program to assure success.

1. Treat spot infestations by pulling and/or herbicide treatment.

2. Conduct periodic surveys to locate plants particularly where treatment has been undertaken.

3. Support programs for development of biological control methods.

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APPENDIX A

Risk Rating of the Susceptibility of Habitat Types Found in Western Montana to Noxious Weed Dominance

Habitat Type	Noxious Weed				
	spotted knapweed	diffuse knapweed	tansy	hounds tongue	leafy spurge
G11 Alpine & barren	0*	0	0	0	0
G12 Mountain meadow	1	0	1	1	2
G13 Mt. grassland	3	2	1	2	3
G14 Foothill grassland	3	3	1	2	3
G16 Alder glade	1	0	2	1	1
G19 Aquatic	0	0	3	1	2
G21 Rockland	1	1	1	1	1
G22 Talus	1	1	1	1	1
G23 Scree (010)	2	2	1	2	2
130 PP/Wheatgrass	3	3	1	2	3
140 PP/Idaho fescue	3	3	1	2	3
141 Idaho fescue phase	3	3	1	2	3
142 rough fescue phase	3	3	1	2	3
160 PP/Bitterbrush	3	3	1	2	3
161 wheatgrass phase	3	3	1	2	3
162 Idaho fescue phase	3	3	1	2	3
170 PP/Snowberry	3	3	1	2	3
210 DF/Wheatgrass	3	3	1	2	3
220 DF/Idaho fescue	3	2	1	2	3
230 DF/Rough fescue	3	3	1	2	3
250 DF/Dwarf huckleberry	1	0	1	1	1
260 DF/Ninebark	1	1	1	1	1
261 ninebark phase	1	1	1	1	1
262 pinegrass phase	2	1	1	2	2
280 DF/Huckleberry	1	1	1	1	1
281 huckleberry phase	1	1	1	1	1
282 kinnikinnick phase	2	1	1	1	2
283 beargrass phase	1	0	1	1	1
290 DF/Twinflower	1	0	1	1	1
291 snowberry phase	1	0	1	1	1
292 pinegrass phase	1	0	1	1	1
293 huckleberry phase	1	0	1	1	1
310 DF/Snowberry	2	2	1	1	2
311 wheatgrass phase	3	3	1	2	3
312 pinegrass phase	2	2	1	1	2
313 snowberry phase	2	2	1	1	2
320 DF/Pinegrass	2	1	1	1	2
321 wheatgrass phase	3	3	1	2	3
322 kinnikinnick phase	2	1	1	1	2
323 pinegrass phase	1	1	1	1	1

* See key provided at the end of Appendix A

Habitat Type	Noxious Weed				
	spotted knapweed	diffuse knapweed	tansy	hounds tongue	leafy spurge
324 PP phase	2	2	1	1	2
330 DF/Elk sedge	2	1	1	1	2
340 DF/Spiraea	3	3	1	2	2
350 DF/Kinnikinnick	3	3	1	2	3
360 DF/Juniper	2	2	1	1	2
370 DF/Heartleaf arnica	1	1	1	1	1
380 DF/Mt. snowberry	2	1	1	1	1
410 S/Horsetail	0	0	2	1	0
420 S/Beadlily	1	0	2	1	1
421 dwarf huckleberry	1	0	1	1	1
422 beadlily phase	1	0	2	1	1
440 S/Goldthread	0	0	2	1	0
450 S/Dwarf huckleberry	1	0	1	1	1
470 S/Twinflower	1	0	1	1	0
510 GF/Beargrass	1	1	1	1	1
520 GF/Beadlily	1	0	2	1	1
521 beadlily phase	1	0	2	1	1
522 sarsaparilla phase	0	0	2	1	0
523 beargrass phase	1	0	1	1	1
530 WRC/Beadlily	1	0	2	1	1
531 beadlily phase	1	0	2	1	1
532 sarsaparilla phase	1	0	2	1	1
533 menziesia phase	0	0	1	1	1
550 WRC/Devil's club	0	0	2	1	0
570 WRC/Beadlily	1	0	2	1	0
571 beadlily phase	1	0	2	1	1
572 sarsaparilla phase	0	0	2	1	0
590 GF/Twinflower	1	0	1	1	1
591 twinflower phase	1	0	1	1	1
592 beargrass phase	1	0	1	1	1
610 AF/Devil's club	0	0	2	1	0
620 AF/Beadlily	1	0	2	1	0
621 beadlily phase	1	0	2	1	0
622 sarsaparilla phase	0	0	2	1	0
623 dwarf huckleberry	1	0	1	1	1
624 beargrass phase	1	0	1	1	1
625 menziesia phase	0	0	1	1	0
630 AF/Goldthread	1	0	2	1	0
640 AF/Dwarf huckleberry	1	0	1	1	1
650 AF/Reedgrass	0	0	1	0	0
651 reedgrass phase	0	0	2	0	0
653 goldthread phase	0	0	2	0	0
654 dwarf huckleberry	0	0	1	0	0
660 AF/Twinflower	1	0	1	1	0
661 twinflower phase	1	0	1	1	0
662 beargrass phase	1	0	1	1	0
663 whortleberry phase	1	0	1	1	0
670 AF/Menziesia	0	0	1	1	0

Habitat Type		Noxious Weed				
		spotted knapweed	diffuse knapweed	tansy	hounds tongue	leafy spurge
680	MH/Menziesia	0	0	1	0	0
690	AF/Beargrass	1	0	1	1	1
691	huckleberry phase	1	0	1	1	1
692	whortleberry phase	1	0	1	0	0
710	MH/Beargrass	1	0	1	1	1
720	AF/Huckleberry	1	0	1	1	1
730	AF/Whortleberry	1	0	1	0	0
731	pinegrass phase	1	0	1	0	0
732	whortleberry phase	1	0	1	0	0
740	AF/Alder	0	0	1	1	0
750	AF/Pinegrass	1	0	1	1	1
820	AF-WBP/Whortleberry	0	0	0	0	0
830	AF/Woodrush	0	0	0	0	0
831	whortleberry phase	0	0	0	0	0
832	menziesia phase	0	0	0	0	0
840	MH/Woodrush	0	0	0	0	0
841	whortleberry phase	0	0	0	0	0
842	menziesia phase	0	0	0	0	0
850	WBP-AF	0	0	0	0	0
860	AL-AF	0	0	0	0	0
870	WBP	0	0	0	0	0

Habitat Type		Noxious Weed			
		dalmation toadflax	goat weed	Canada thistle	musk thistle
G11	Alpine & barren	0	0	0	0
G12	Mountain meadow	1	1	2	2
G13	Mt. grassland	3	3	2	1
G14	Foothill grassland	3	3	2	1
G16	Alder glade	0	1	1	1
G19	Aquatic	1	1	2	2
G21	Rockland	1	1	1	1
G22	Talus	1	1	1	1
G23	Scree (010)	2	2	1	1
130	PP/Wheatgrass	3	3	2	1
140	PP/Idaho fescue	3	3	2	1
141	Idaho fescue phase	3	3	2	1
142	rough fescue phase	3	3	2	1
160	PP/Bitterbrush	3	3	2	1
161	wheatgrass phase	3	3	2	1
162	Idaho fescue phase	3	3	2	1
170	PP/Snowberry	2	3	2	1
210	DF/Wheatgrass	3	3	2	1
220	DF/Idaho fescue	2	3	2	1
230	DF/Rough fescue	3	3	2	1
250	DF/Dwarf huckleberry	0	1	1	1

Habitat Type	Noxious Weed			
	dalmation toadflax	goat weed	Canada thistle	musk thistle
260 DF/Ninebark	1	1	1	1
261 ninebark phase	1	1	1	1
262 pinegrass phase	1	2	1	1
280 DF/Huckleberry	1	1	1	1
281 huckleberry phase	1	0	1	1
282 kinnikinnick phase	1	2	1	1
283 beargrass phase	1	0	1	1
290 DF/Twinflower	1	1	1	1
291 snowberry phase	1	1	1	1
292 pinegrass phase	1	1	1	1
293 huckleberry phase	0	0	1	1
310 DF/Snowberry	1	2	1	1
311 wheatgrass phase	1	3	1	1
312 pinegrass phase	1	2	1	1
313 snowberry phase	1	2	1	1
320 DF/Pinegrass	1	2	1	1
321 wheatgrass phase	2	3	1	1
322 kinnikinnick phase	1	2	1	1
323 pinegrass phase	1	1	1	1
324 PP phase	1	2	1	1
330 DF/Elk sedge	1	1	1	1
340 DF/Spiraea	2	3	1	1
350 DF/Kinnikinnick	2	2	1	1
360 DF/Juniper	1	1	1	1
370 DF/Heartleaf arnica	1	1	1	1
380 DF/Mt. snowberry	1	2	1	1
410 S/Horsetail	0	0	0	0
420 S/Beadlily	0	1	1	1
421 dwarf huckleberry	0	1	1	1
422 beadlily phase	0	1	1	1
440 S/Goldthread	0	0	1	1
450 S/Dwarf huckleberry	0	1	1	1
470 S/Twinflower	0	0	1	1
510 GF/Beargrass	1	1	1	1
520 GF/Beadlily	1	1	1	1
521 beadlily phase	1	1	1	1
522 sarsaparilla phase	0	1	1	1
523 beargrass phase	1	1	1	1
530 WRC/Beadlily	1	1	1	1
531 beadlily phase	1	0	1	1
532 sarsaparilla phase	0	1	1	1
533 menziesia phase	0	0	1	0
550 WRC/Devil's club	0	0	0	0
570 WRC/Beadlily	0	0	1	1
571 beadlily phase	0	0	1	1
572 sarsaparilla phase	0	0	1	1
590 GF/Twinflower	0	1	1	1
591 twinflower phase	0	0	1	1

Habitat Type	Noxious Weed			
	dalmation toadflax	goat weed	Canada thistle	musk thistle
592 beargrass phase	0	1	1	1
610 AF/Devil's club	0	0	0	0
620 AF/Beadlily	0	1	1	1
621 beadlily phase	0	1	1	1
622 sarsaparilla phase	0	1	1	1
623 dwarf huckleberry	0	1	1	1
624 beargrass phase	0	1	1	1
625 menziesia phase	0	0	1	0
630 AF/Goldthread	0	1	1	1
640 AF/Dwarf huckleberry	0	1	1	1
650 AF/Reedgrass	0	0	0	0
651 reedgrass phase	0	0	0	0
653 goldthread phase	0	0	0	0
654 dwarf huckleberry	0	0	0	0
660 AF/Twinflower	0	0	1	1
661 twinflower phase	0	0	1	1
662 beargrass phase	0	0	1	1
663 whortleberry phase	0	0	1	1
670 AF/Menziesia	0	0	1	1
680 MH/Menziesia	0	0	1	1
690 AF/Beargrass	0	1	1	1
691 huckleberry phase	0	1	1	1
692 whortleberry phase	0	0	1	1
710 MH/Beargrass	0	1	1	1
720 AF/Huckleberry	0	0	1	1
730 AF/Whortleberry	0	0	1	0
731 pinegrass phase	0	0	1	1
732 whortleberry phase	0	0	1	1
740 AF/Alder	0	0	0	1
750 AF/Pinegrass	0	1	1	1
820 AF-WBP/Whortleberry	0	0	1	0
830 AF/Woodrush	0	0	1	0
831 whortleberry phase	0	0	1	0
832 menziesia phase	0	0	1	0
840 MH/Woodrush	0	0	1	1
841 whortleberry phase	0	0	1	1
842 menziesia phase	0	0	1	1
850 WBP-AF	0	0	1	0
860 AL-AF	0	0	1	0
870 WBP	0	0	1	0

KEY

3 - High risk - Noxious weeds may frequently dominate native vegetation following disturbance or through invasion into an undisturbed community.

2 - Moderate risk - Noxious weeds may dominate interspaces of native vegetation but sites generally have a limiting factor which prevents full development of the weed.

1 - Low risk - Noxious weeds occur as single plants or small groups and will not dominate native vegetation.

0 - No risk - Environmental conditions are unsuitable for the survival of the weed.

APPENDIX B

The following tables present the expected acres that could be infected by various noxious weeds and the severity of that infection. These estimates are based on the acres of the various habitat types found on each forest. Severity ratings represent the following conditions:
High - The weed can dominate the site to the exclusion of other ground vegetation; moderate - a portion of the site may be dominated (interspaces between shrubs) or a series of events may result in weed dominance but generally sites have some limiting factor which restricts them; low - weeds may be present as single plants but except under highly unusual conditions, cannot dominate the site; zero - no risk, environmental conditions are unsuitable for the survival of the weed.

Acres of Forest Land on the Bitterroot, Lolo and Flathead National Forests by Risk Category.

BITTERROOT FOREST WEED RISK

WEED	HIGH (3)	MODERATE (2)	LOW (1)	NONE (0)
Spotted Knapweed	77,238 9.3%	177,192 21.4%	456,881 55.1%	117,295 14.2%
Diffuse Knapweed	62,447 7.5%	41,333 5.0%	299,497 36.1%	425,299 51.3%
Tansy	130 T	22,541 2.7%	746,521 90.1%	59,414 7.2%
Houndstongue	0	61,222 7.4%	707,517 85.4%	59,867 7.2%
Leafy Spurge	77,238 9.3%	178,087 21.5%	434,063 52.4%	139,218 16.8%
Dalmation Toadflax	25,149 3.0%	2,355 0.3%	337,542 40.7%	463,560 55.9%
Goatweed	77,238 9.3%	166,803 20.1%	464,041 56.0%	120,524 14.5%
Canada Thistle	0	31,522 3.8%	797,084 96.2%	0
Musk Thistle	0	895 0.1%	767,844 92.7%	59,867 7.2%

LOLO FOREST WEED RISK

WEED	HIGH (3)	MODERATE (2)	LOW (1)	NONE (0)
Spotted Knapweed	71,982 3.5%	359,565 17.5%	1,312,794 63.7%	315,591 15.3%
Diffuse Knapweed	61,007 3.0%	206,573 10.0%	770,018 37.4%	1,022,330 49.6%
Tansy	0	225,762 12.4%	1,676,107 81.4%	128,124 6.2%
Houndstongue	0	307,700 14.9%	1,602,962 77.9%	149,331 7.2%
Leafy Spurge	71,965 3.5%	364,057 17.7%	786,024 38.2%	837,947 40.7%
Dalmation Toadflax	56,910 2.8%	174,030 8.4%	967,361 47.0%	861,692 41.8%
Goatweed	71,974 3.5%	356,974 17.3%	1,292,321 62.7%	338,724 16.4%
Canada Thistle	0	62,261 3.0%	1,992,527 96.7%	5,205 0.3%
Musk Thistle	0	4,475 0.2%	1,919,231 93.2%	136,287 6.6%

FLATHEAD FOREST WEED RISK

WEED	HIGH (3)	MODERATE (2)	LOW (1)	NONE (0)
Spotted Knapweed	0	92,989 5.3%	1,372,249 77.9%	297,249 16.9%
Diffuse Knapweed	0	0	106,169 6.0%	1,656,318 94.0%
Tansy	0	622,923 35.3%	875,675 49.7%	263,889 15.0%
Houndstongue	0	6,873 0.4%	1,140,045 64.7%	615,569 34.9%
Leafy Spurge	0	92,989 5.3%	1,091,418 61.9%	578,080 32.8%
Dalmation Toadflax	0	0	136,078 7.7%	1,626,409 92.3%
Goatweed	0	92,989 5.3%	1,396,221 79.2%	273,277 15.5%
Canada Thistle	0	0	1,734,238 98.4%	28,249 1.6%
Musk Thistle	0	0	1,235,815 70.1%	526,672 29.9%

APPENDIX C

The following tables present the most recent estimate of noxious weeds on each of the National Forests.

Estimate of the Acres of the Bitterroot, Lolo and Flathead Forests Presently Infested by Noxious Weeds.

Noxious Weed	Bitterroot	Lolo	Flathead
Spotted Knapweed	274,000	225,000	15,000
Diffuse Knapweed	<100	200	100
Tansy	<100	500	<100
Houndstongue	2,500	<100	1,800
Leafy Spurge	<100	3,400	<50
Dalmation Toadflax	0	<50	<50
Goatweed	1,000	6,400	2,700
Canada Thistle	500	8,000	100
Musk Thistle	<50	<100	<50

APPENDIX D

The following models have been developed to predict the anticipated invasion of spotted knapweed on roads. They are based on the assumption that seed will reach the road through vehicle traffic or the plant is already well established adjacent to the project site. It is also assumed that no grass seeding will be done or attempts made to prevent the spread of seed to the site. These treatments will reduce the threat of establishment on the sites. At the same time conditions that show a zero for knapweed coverage are not threatened by knapweed.

MODEL SELECTION

Model 1 may be used when the road is in place or a prediction of sun angle can reasonably be made. A value of 23 can be used as a default value for sun angle. This value represents the average for all sites on the three Forests.

If there is limited data available, Model 2 should be used.

USE OF THE MODELS

Information used to develop this model came from the following habitat types. Types not sampled may not respond as predicted.

Habitat Types Sampled	Habitat Types Sampled
Douglas-fir/ninebark	subalpine fir/beadlily
Douglas-fir/huckleberry	subalpine fir/dwarf huckleberry
Douglas-fir/snowberry	subalpine fir/beargrass
Douglas-fir/pinegrass	subalpine fir/alder
grand fir/beargrass	

Roads should be broken into segments by aspect for evaluation. Sections that will cross a clearcut will generally have a crown closure of zero unless the road is at the top or bottom of the unit.

EXPECTED KNAPWEED COVERAGE CLASS ON ROAD SHOULDERS ON SOUTHWEST ASPECTS (202-247 DEGREES)

CROWN CLOSURE/	SUN ANGLE 5	10	15	20	30	40	50
0	8	6	5	5	4	4	3
5	6	5	5	4	3	3	2
10	6	5	4	4	3	2	2
15	6	5	4	3	3	2	2
20	6	4	4	3	2	2	2
30	5	4	3	3	2	2	1
40	5	4	3	3	2	1	1
50	5	3	3	2	2	1	1
60	4	3	2	2	1	1	P
70	4	3	2	2	1	1	T

EXPECTED KNAPWEED COVERAGE CLASS ON ROAD SHOULDERS ON SOUTH ASPECTS (158-202 DEGREES)

CROWN CLOSURE/	SUN ANGLE 5	10	15	20	30	40	50
0	7	6	5	5	4	3	3
5	6	5	4	4	3	3	2
10	6	5	4	3	3	2	2
15	6	4	4	3	2	2	2
20	5	4	3	3	2	2	1
30	5	4	3	3	2	1	1
40	5	3	3	2	2	1	1
50	4	3	2	2	1	1	P
60	4	3	2	2	1	1	T
70	4	3	2	1	1	P	0

EXPECTED KNAPWEED COVERAGE CLASS ON ROAD SHOULDERS ON SOUTHEAST ASPECTS (113-157 DEGREES)

CROWN CLOSURE/	SUN ANGLE 5	10	15	20	30	40	50
0	7	6	5	4	4	3	3
5	6	5	4	3	3	2	2
10	6	4	4	3	2	2	2
15	5	4	3	3	2	2	1
20	5	4	3	3	2	1	1
30	5	3	3	2	2	1	1
40	4	3	2	2	1	1	P
50	4	3	2	2	1	P	T
60	4	3	2	1	1	P	0
70	4	2	2	1	P	0	0

EXPECTED KNAPWEED COVERAGE CLASS ON ROAD SHOULDERS ON WEST ASPECTS (248-292 DEGREES)

CROWN	SUN ANGLE						
CLOSURE/	5	10	15	20	30	40	50
0	6	5	5	4	3	3	2
5	6	4	4	3	2	2	2
10	5	4	3	3	2	2	1
15	5	4	3	3	2	1	1
20	5	4	3	2	2	1	1
30	4	3	2	2	1	1	P
40	4	3	2	2	1	P	0
50	4	3	2	1	1	P	0
60	4	2	2	1	P	0	0
70	3	2	1	1	P	0	0

EXPECTED KNAPWEED COVERAGE CLASS ON ROAD SHOULDERS ON EAST ASPECTS (68-112 DEGREES)

CROWN	SUN ANGLE						
CLOSURE/	5	10	15	20	30	40	50
0	6	5	4	3	3	3	2
5	5	4	3	3	2	2	1
10	5	4	3	3	2	1	1
15	5	4	3	2	2	1	1
20	4	3	3	2	1	1	P
30	4	3	2	2	1	1	T
40	4	3	2	1	1	P	0
50	4	2	2	1	P	0	0
60	3	2	1	1	T	0	0
70	3	2	1	1	0	0	0

EXPECTED KNAPWEED COVERAGE CLASS ON ROAD SHOULDERS ON NORTHWEST ASPECTS (293-337 DEGREES)

CROWN	SUN ANGLE						
CLOSURE/	5	10	15	20	30	40	50
0	6	5	4	3	3	2	2
5	5	4	3	3	2	1	1
10	5	3	3	2	2	1	1
15	4	3	3	2	1	1	P
20	4	3	2	2	1	1	P
30	4	3	2	1	1	P	0
40	4	2	2	1	P	0	0
50	3	2	1	1	T	0	0
60	3	2	1	1	0	0	0
70	3	2	1	P	0	0	0

EXPECTED KNAPWEED COVERAGE CLASS ON ROAD SHOULDERS ON NORTH ASPECTS (338-22 DEGREES)

CROWN	SUN ANGLE						
CLOSURE/	5	10	15	20	30	40	50
0	6	4	4	3	2	2	2
5	5	4	3	2	2	1	1
10	4	3	3	2	1	1	P
15	4	3	2	2	1	1	T
20	4	3	2	2	1	P	0
30	4	2	2	1	P	0	0
40	3	2	1	1	T	0	0
50	3	2	1	1	0	0	0
60	3	2	1	P	0	0	0
70	2	1	1	0	0	0	0

EXPECTED KNAPWEED COVERAGE CLASS ON ROAD SHOULDERS ON NORTHWEST ASPECTS (293-337 DEGREES)

CROWN	SUN ANGLE						
CLOSURE/	5	10	15	20	30	40	50
0	5	4	3	3	2	2	1
5	4	3	3	2	1	1	P
10	4	3	2	2	1	1	T
15	4	3	2	1	1	P	0
20	4	2	2	1	1	0	0
30	3	2	1	1	T	0	0
40	3	2	1	1	0	0	0
50	3	1	1	P	0	0	0
60	2	1	1	0	0	0	0
70	2	1	P	0	0	0	0

MODEL 2

KNAPWEED COVERAGE CLASS POTENTIAL BASED ON CROWN CLOSURE AND ASPECT

CROWN	ASPECT							
CLOSURE/	SW	S	SE	W	E	NW	N	NE
0	5	5	5	4	4	4	3	3
5	4	4	3	3	3	2	2	2
10	4	3	3	2	2	2	1	1
15	3	3	2	2	2	1	1	1
20	3	2	2	2	1	1	1	P
30	2	2	1	1	1	P	0	0
40	2	1	1	1	T	0	0	0
50	1	1	P	0	0	0	0	0
60	1	P	0	0	0	0	0	0
70	P	0	0	0	0	0	0	0

DEFINITIONS

Crown Closure - An estimate of shading of vegetative crowns on the road shoulder. It includes both trees and shrubs.

Sun Angle - The average of readings made at an azimuth of 110 and 250 degrees. The angle is measured from the horizontal to the object that intercepts the sun's rays.

Knapweed Coverage Class - The estimated coverage of knapweed plants in percent after the plants have bolted.

Coverage Classes	Percent Coverage	Risk Rating
0	0	0
T	.1 - < 1	0
P	1 - < 5	1
1	5 - <15	1
2	15 - <25	2
3	25 - <35	2
4	35 - <45	3
5	45 - <55	3
6	55 - <65	3
7	65 - <75	3
8	75 - <85	3
9	85 - <95	3

APPENDIX E

The following models are for use in predicting the potential impact of noxious weeds on disturbed sites. Information collected from 68 plots was used to develop these models. Correlations with site factors were found only for Canada thistle and spotted knapweed. Collection of additional data for goatweed may aid development of a model for it.

The Canada thistle model is based on information collected on the Douglas-fir/pinegrass, grand fir/beadlily, grand fir/twinflower, and subalpine fir/beargrass habitat types.

Information for the spotted knapweed model came from the following habitat types:

Douglas-fir/rough fescue	Douglas-fir/pinegrass
Douglas-fir/snowberry	grand fir/twinflower
Douglas-fir/ninebark	grand fir/beadlily
Douglas-fir/dwarf huckleberry	subalpine fir/beargrass

Data was collected using 1/5 acre plots and included:

Site description - habitat type, aspect, slope, elevation, percent bare soil, rock pavement, rock, moss and lichen, litter and debris, and basal vegetation

Overstory information - tree species, age, crown closure, and basal area

Understory information - tree species, number, and size class

Ground cover - percent coverage of shrubs, graminoids and forbs by species

Data was analyzed using the SPSS analysis package available at the Fort Collins Computer Center.

Thistle Model

Aspect	Percent Coverage
N	31
NE	37
NW	26
E	20
W	14
SE	8
S	3
SW	0

This model had an R2 of 0.34 and was significant at the 0.07 percent level.

[illegible] and [illegible] development of [illegible] [illegible].

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Sons.

Info [illegible] [illegible] [illegible] [illegible]

[illegible]
[illegible]
[illegible]
[illegible]

[illegible] was collected [illegible] [illegible] [illegible]

Site description - Habit [illegible] rock pavement [illegible] [illegible]

Overstory information - [illegible]

Understory information - [illegible]

Ground cover - percent cover [illegible] [illegible].

analyzed [illegible] SPSS analysis [illegible] Center.

Knapweed Model

Knapweed coverage in percent = 29.175 - (tree crown cover)(0.472) -
(total shrub coverage)(1.409) +
(coverage of ceanothus)(1.19) -
(coverage of pearly-everlasting)(1.338)

This model had a R2 of 0.36 and was significant at the 0.79 percent level.

APPENDIX F

A COMPARISON OF NOXIOUS WEED CHARACTERISTICS

Characteristic	Noxious Weed				
	spotted knapweed	diffuse knapweed	tansy	hounds tongue	leafy spurge
Flower	purple rarely white	white	yellow	purple or pinkish	yellowish-green
Height - feet	1-3	1.5-2.5	3	0.7-2.5	2-3
Life expectency	3-5	2	perennial	2	perennial
Shade tolerance	very intolerant	very intolerant	tolerant	tolerant	moderate
Environment	valley to montane	valley	riparian	all but high elevation	valley to lower montane
Soil type	wide range gravelly	wide range gravelly	?	nitrogen-rich not peaty or clay	all
Germination needs moisture	55-70%	drier than spotted	?	12%	?
temperature	45-93		?	32-50	wide range
Seed depth which limits germination	1"	3/4"	?	>0.4"	>2"
Seed production/plant	1000	1000	?	2500	140
Seed dispersal	animals people equipment	wind	?	domestic animals people	projected water birds
Seed bank-years	8	8?	?	2	8
Vegetative reproduction	from root crowns	no	no	rhizome	root buds
limiting growth factor	limited light excess moisture	limited light excess moisture	?	acid-soil	none known

Characteristics	Noxious Weed			
	dalmation toadflax	goat weed	Canada thistle	musk thistle
Flower	showy yellow	orange-yellow	purple dioecious	nodding purple
Height - feet	2	3	4	2-5
Life expectency	perennial	perennial	perennial	2
Shade tolerance	intolerant	moderate	very intolerant	intolerant
Environment	dry valley	valley to montane	cool moist	cool moist
Soil type	calcareous	sandy gravelly	rich clay all but peat	limestone derived
Germination needs moisture	?	?	moist	moist
temperature	41-86	?	68-86	?
Seed depth which limits germination	>1"	?	1.2"	?
Seed production per plant	400,000 per plant group	25000	1500	8000
Seed dispersal	?	animals wind	water animals wind	wind
Seed bank-years	10	?	20	?
Vegetative reproduction	lateral root buds	runners from rootstock	rhizome	no
limiting growth factor	competition	cool temp.	shade,wet sites competition	competition, drought, low fertility

1= Wilderness — Law a-l.

2- PVT lands - Boundary. Intermingled lands

3.- Intern lands Internal Problems

I Inventory ≠

Phase II PLAN

Campground T.C.

gravel Pit. Mtn Meadows

& Wvy Rd.

Inventory on S.P.

(Boulder Button
Orange Hawk Weed
Beaver Creek
(Star Thistle
(Whitetop

G.P. Inventory (- PCH) (Map)

(BOOK TO DISTRICT)

T.C.

= Gravel Pits < Trial Inventory

— Campground Swim area

— Road Maint (Alan Simpson Jim Monroe)

(Hand Pull) Disposal

Big Mtn - Map + Control
Town 12, Chapt 1

Prepare Handout BOOK =

Grazing (AUM's)

North Fork Road

Ruin accesses

Private Ownership

Gravel Pits

Bears + Weeds

GNP access

Canada

Big Mtn

Koot + State

Road Closure: